



NEPAL ELECTRICITY AUTHORITY
Medium Voltage Grid Development Department, Transmission Directorate

BIDDING DOCUMENT

For

**Package-1: Design Build Plant and Works for Construction of
Birauta 132/11kV Substation and Associated Transmission and
Distribution Lines in Pokhara**

(Bid Identification No.: ICB/NEA/UTDSIP/82/83-01)

Volume 4 of 4

Employer's Requirements
For Distribution Line Work

Employer: Nepal Electricity Authority
Country: Federal Democratic Republic of Nepal
Loan No.: NE-P13
Project: Urban Transmission and Distribution System Improvement Project
Contract: Package-1: Design Build Plant and Works for Construction of
Birauta 132/11kV Substation and Associated Transmission and
Distribution Lines in Pokhara

October 2025





Table of Contents

VOLUME 1 OF 4

Invitation for Bids (IFB)

PART 1 - Bidding Procedures

- Section I. Instructions to Bidders (ITB)
- Section II. Bid Data Sheet (BDS)
- Section III. Evaluation and Qualification Criteria (EQC)
- Section IV. Bidding Forms (BF)
- Section V. Eligible Source Countries of Japanese ODA Loans (ESC)

PART 2 - Employer's Requirements

- Section VI. Employer's Requirements (ER)

PART 3 - Conditions of Contract and Contract Forms

- Section VII. General Conditions (GC)
- Section VIII. Particular Conditions (PC)
- Section IX. Contract Forms (CF)

VOLUME 2 OF 4

Part 2A: Employer's Requirements for Substation Work

- Section VI.A1 Scope of Work
- Section VI.A2 Technical Specification
- Appendix-A1 Technical Particulars
- Appendix-A2 Drawings forming part of Specifications (in Volume of Annex)
- Appendix-A3 Topographical and Geotechnical Investigation Report

VOLUME 3 OF 4

Part 2B: Employer's Requirements for Transmission Line Work

- Section VI.B1 Scope of Work
- Section VI.B2 Technical Specification
- Appendix-B1 Technical Particulars
- Appendix-B2 Drawings forming part of Specifications (in Volume of Annex)
- Appendix-B3 Topographical and Geotechnical Investigation Report

VOLUME 4 OF 4

Part 2C: Employer's Requirements for Distribution Line Work

- Section VI.C1 Scope of Work
- Section VI.C2 Technical Specification
- Appendix-C1 Technical Particulars
- Appendix-C2 Drawings forming part of Specifications (in Volume of Annex)

VOLUME OF ANNEX

- ANNEX-1 Drawings for Substation Work
- ANNEX-2 Drawings for Transmission Line Work
- ANNEX-3 Drawings for Distribution Line Work





PART – 2C:
EMPLOYER’S REQUIREMENTS FOR
DISTRIBUTION LINE WORK

SECTION VI.C1: SCOPE OF WORK



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SECTION VI.C1: SCOPE OF WORK

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
1	GENERAL	1
2	SCOPE OF WORK.....	3
2.1	Construction of 11kV underground and overhead distribution lines from Birauta substation.....	3
2.2	Undergrounding of low voltage (LV) network on the roads where MV network is to be undergrounded	4
2.3	Installation of SCADA system and communication system for distribution lines for the above 8 MV distribution feeders	5
2.4	Common Requirements	5
3	TERMINAL POINTS	5
3.1	General	5
3.2	Distribution Line Work in Birauta Substation.....	6
3.3	Interface with Existing Distribution Facilities	6
4	SITE ENVIRONMENTAL CONDITIONS.....	7
4.1	Metrological and Climate condition	7
4.2	Electrical condition.....	7
5	ELECTRICITY, WATER, GAS, AND OTHER SERVICES	7
6	MAJOR EQUIPMENT AND SPARE PARTS	7
6.1	Power Cable and Fiber Optics (FO) Cable	7
6.1.1	11kV underground (UG) cable	7
6.1.2	11kV overhead (OH) conductor.....	8
6.1.3	LT underground (UG) cable	8
6.1.4	LT Service cable	8
6.1.5	Fiber Optic (FO) cable and the accessories.....	8
6.2	Handhole	8
6.3	Gang Operated (G.O) Load Break Switch	8



6.4	Ring Main Unit (RMU)	8
6.5	Equipment for Distribution Management System	9
6.6	LT distribution pillar panel	9
6.7	Utility Pole and the accessories	9
6.8	Mandatory Spare Parts and Recommended Spare Parts	9
7	TRAINING	9
7.1	Training at Factory	9
7.2	Training at Site	10
8	FACTORY ACCEPTANCE TEST (FAT) WITNESSED BY THE EMPLOYER AND THE ENGINEER	10



Abbreviations

Abbreviation	Meaning
AAA	All Aluminium Alloy
ABC (AB Cable)	Aerial Bundled Conductor (Aerial Bundled Cable)
ACB	Air Circuit Breaker
ACSR	Aluminium Conductor Steel Reinforced
AI/AO	Analog Input/Analog Output
AMR	Automated Meter Reading
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BFD	Bidirectional Forwarding Detection
BPDU	Bridge Protocol Data Unit
BS	British Standard
CDC	Compensation Determination Committee
CE	Conformité Européenne
CEMP	Construction Environmental Management Plan
CIM	Common Information Model
CISPR	Comité International Spécial des Perturbations Radioélectriques
CPM	Central Processing Module
CRCA steel	Cold Rolled Close Annealed steel
CSA	Canadian Standards Association
CT	Current Transformer
DC	Data Center or Direct Current
DCC	Distribution Command and Control Center (Distribution Control Center)
DCU	Data Concentrator Unit
DI/DO	Digital Input/Digital Output
DMS	Distribution Management System
DMZ	Demilitarized Zone
DOR	Department of Road
DoS	Denial of Service
DR	Disaster Recovery System
DT	Distribution Transformer
DTS	Dispatcher Training Simulator
DWSW	Dual Window Single Mode
E/F	Earth Fault
EC	Electrolytic Copper
EMI/EMC	Electromagnetic Interference/Electromagnetic Compatibility



EMP	Environmental Management Plan
ESB	Enterprise Service Bus
ESCR	Environmental Stress Crack Resistance
FAT	Factory Acceptance Test
FCC	Federal Communications Commission
FMS	Fiber Management System
FMST	Fault Management and System Restoration
FO	Fiber Optic
FODP	Fiber Optic Distribution Panel
FOTS	Fiber Optic Transmission System
FPI	Fault Passage Indicator
FRP	Fiber Reinforced Plastic
FRTU	Feeder Remote Terminal Unit
FTP	File Transfer Protocol
G.I.	Galvanized Iron
GPRS	General Packet Radio Service
GRM	Grievance Redress Mechanism
GSM	Global System for Mobile Communication
GW	Gateway or Ground Wire
HDPE	High Density Polyethylene
HRC fuse	High Rupturing Capacity fuse
HSO	Health and Safety Officer
HTTP	Hypertext Transfer Protocol
I/O	Input/Output
ICCP	Inter-Control Center Communication Protocol
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Ingress Protection
IPC	Insulated Piercing Connector
IS	Indian Standard
ISO	International Organization for Standardization
ISR	Information Storage and Retrieval Database
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
JICA	Japan International Cooperation Agency
JSSS	JICA Standard Safety Specification
LBS	Load Break Switch
LBS	Load Break Switch
LCD	Liquid Crystal Display



LDC	Load Dispatch Center
LDP	Label Distribution Protocol
LILO	Loop-in and Loop-out
LIU	Line Interface Unit
LSP mode	Language Server Protocol mode
LV	Low Voltage
M.F.R	Melt Flow Rate
MADM	Multi-attribute Decision-Making
MCC	Master Control Center
MCCB	Moulded Case Circuit Breaker
MFA	Multi-Factor Authentication
MFM	Multi-Function Meter
MFT	Multi-Function Transducer
MMI	Man-Machine Interface
MOC	Master Operational Center
MPLS	Multiprotocol Label Switching
MSP	Multiplex Section Protection
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
MV	Medium Voltage
NE	Network Element
NEA	Nepal Electricity Authority
NEMA	National Electrical Manufacturers Association
NMS	Network Management System
NNI	Network Node Interface
NO/NC	Normally Open/Normally Closed
NOC	Network Operating Center
NTC	Nepal Telecom
O&M	Operation and Maintenance
OAM	Operation, Administration, and Maintenance
O/C	Overcurrent
OAG	Open Applications Group
ODF	Optical Distribution Frame
OH	Overhead
OMS	Outage Management System
OPC	Open Platform Communications
OTDR	Optical Time Domain Reflectometer
PCMT	Portable Configuration and Maintenance Terminal
PIO	Process Input/Output



PLB-HDPE	Permanently Lubricated High Density Polyethylene
PN	Pressure Nominal
PT	Potential Transformer
PVC	Polyvinyl Chloride
RAID	Redundant Arrays of Inexpensive Disks
RCC	Reinforced Cement Concrete
RDC	Regional Control Center
RF	Radio Frequency
RMS	Revenue Management System
RMU	Ring Main Unit
RoHS	Restriction of Hazardous Substances
RTU	Remote Terminal Unit
RU	Rack Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SF6	Sulfur Hexafluoride
SHM	Stakeholders' Meeting
SLA	Service Level Agreement
SLDC	State Load Dispatch Center
SMA	Sub-Miniature version A
SNCP	Sub-Network Connection Protection
SOA	Service Oriented Architecture
SOC	Security Operating Center
SOE	Sequence of Events
STM	Synchronous Transport Module
TCP	Transmission Control Protocol
TMN	Telecommunication Management Network
TSP	Total Suspended Particulate
UDP	User Datagram Protocol
UG	Underground
UL	Underwriters Laboratories
UNI	User Network Interface
UPS	Uninterruptible Power Supply
VLAN	Virtual Local Area Network
VPLS	Virtual Private LAN Service
VPN	Virtual Private Network
VT	Voltage Transformer
XLPE	Cross-linked Polyethylene



XML	Extensible Markup Language



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1 GENERAL

(1) Project Background

The Japan International Cooperation Agency (hereinafter referred to as “JICA”) conducted an “information gathering/confirmation survey on urban transmission and distribution network development in Nepal” (hereinafter referred to as “Data Collection Survey”) in 2019 and a Preparatory Survey on the Transmission and Distribution System Improvement Project in Urban Areas (hereinafter referred to as “Preparatory Survey”) in 2021, respectively. The government of Nepal has received a loan from JICA to finance the “Urban Transmission and Distribution System Improvement Project” (hereinafter referred to as “the Project”) to improve and upgrade the transmission and distribution system in urban areas in Nepal.

The objective of the Project is to improve the transmission and distribution system in urban areas by developing new and/or upgrading the existing transmission and/or distribution system, including grid substations and related equipment, thereby contributing to economic growth in Nepal. The targeted cities for improving the transmission and distribution system under this project are Pokhara and Kathmandu, as detailed below.

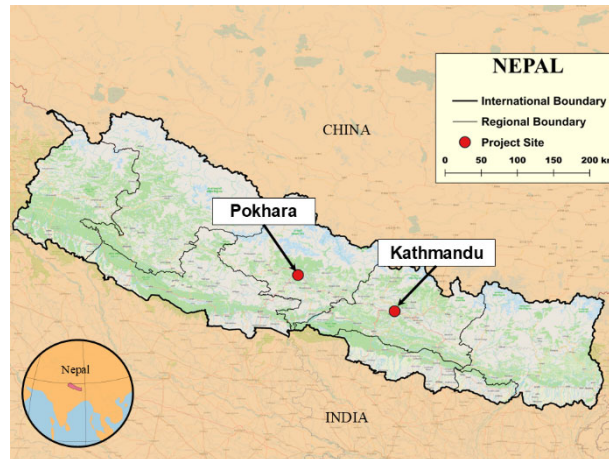


Fig C1-1 Project Site Location

(2) Background of Pokhara Project for Package No.1

The project site for Package No.1 under the Project is located in Pokhara. Pokhara is a major tourist zone and the second most populated city next to Kathmandu. The power demand is rapidly increasing due to the development of tourism, and the new Pokhara international airport has commenced operation as a gateway to worldwide tourism. The power consumed in Pokhara city is currently supplied by the 132/11kV Pokhara substation (transformer capacity: 2 units x 30MVA = 60MVA in total) alone, which will not be able to meet the rapidly increasing power demand in the near future, making this Subproject the first priority.

Under these circumstances, a new 132/11kV substation (60MVA = 30MVA x 2 units transformer capacity) will be constructed at Birauta to increase the power supply capacity to Pokhara city and to extend new 11kV distribution feeders from the new Birauta substation. This new substation will be connected to the existing 132kV single circuit overhead transmission line from Lekhnath substation to Syangja substation through 132kV underground cables by LILo connection. Therefore, a new LILo branch tower will be erected under the existing 132kV overhead line to connect with the new Birauta substation.

The following drawing shows the diagram for connection of the new 132/11kV substation at Birauta.

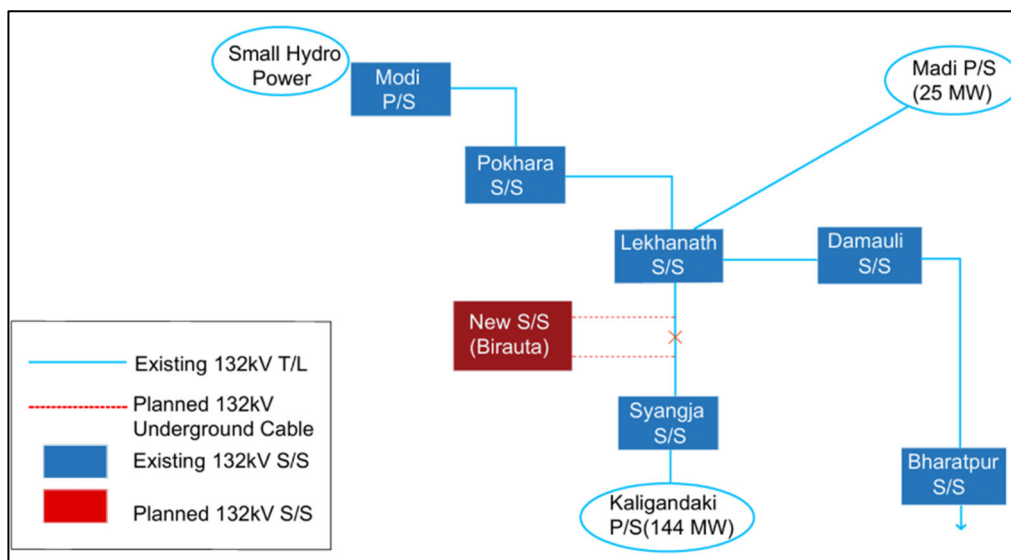


Fig C1-2 Diagram for Connection of New Birauta Substation

The location of construction site is shown in the map below.

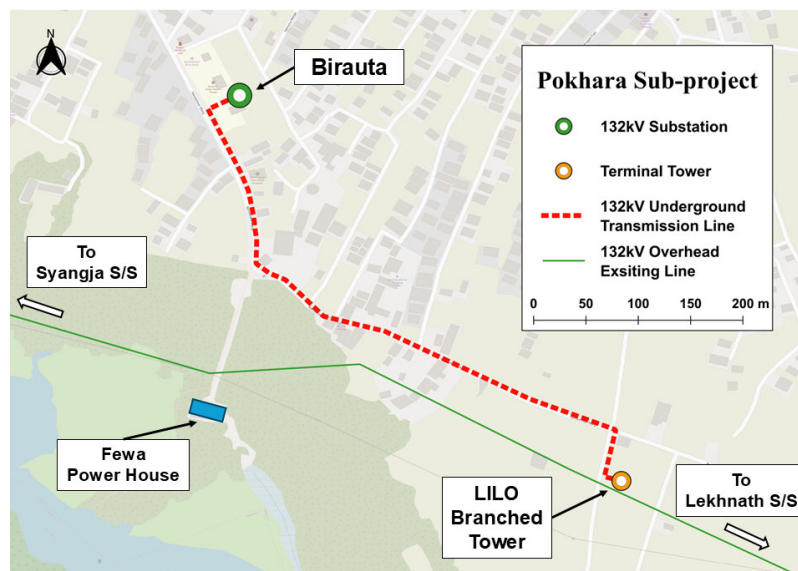


Fig C1-3 Site Location Map of Pokhara Project

The scope of the Project shall include the following three (3) sections, i.e.

- (1) Substation Work,
- (2) Transmission Line Work, and
- (3) Distribution Line Work.

Volume-4 of the Bidding Documents mainly stipulates the Employer's requirements for Distribution Line Work.

The scope of Works (hereinafter said, "Scope of Work") is described in the following clauses and in the respective Chapters of the Specification of Section VI-C. All works not expressly called for in the Specification, but necessary for the completion of the Works shall be performed and furnished

by the Contractor at no additional cost to the Employer on lump sum basis.

The Scope of Work shall comprise all the necessary works for construction of the 11kV distribution lines from 132/11kV Birauta substation to the existing 11kV distribution line and the associated low voltage (LV) distribution lines (not including distribution transformers) on turnkey basis, survey, design, manufacture, testing, supply, insurance, delivery to site, erection/installation in appropriate manners, training, setting to work, underground XLPE power cable, optical fiber cable, cable joint, cable sealing end, lightning arrester, associated accessories and the replacement and/or adjustment of defective material and workmanship for the duration of the 12 month warranty period of the distribution line.

The bidder is required to ascertain for himself whether any additional plant or works are necessary to make the distribution lines required in the scope of work complete and in working order on completion of the contract in accordance with the Specification and Bid Drawings.

Besides, the Contractor shall fully comply with the JICA Standard Safety Specification (JSSS) and Particular Safety Specification, as stipulated in the relevant Chapter in the Technical Specification.

The Contractor shall prepare a sufficiently flexible and realistic work schedule that takes into full account the seasonal characteristics and monsoon conditions specific to Nepal. The Contractor is required to strictly adhere to the Time for Completion as stipulated in the Contract. Any delay in Taking Over due to the impact of the monsoon season on construction activities shall not be accepted as a valid reason for extension of time.

2 SCOPE OF WORK

The Scope of Work for Distribution Line Work consists of the following major components:

- (a) Construction of 11kV underground distribution lines, and 11kV overhead distribution lines for 8 feeders from Birauta substation,
- (b) Undergrounding of LV distribution lines connected to the above 8 feeders of 11kV distribution line network, and
- (c) Installation of SCADA/DMS system and Communication system for distribution lines for the above 8 feeders

2.1 Construction of 11kV underground and overhead distribution lines from Birauta substation

The eight (8) 11kV distribution line feeders from Birauta 132/11kV substation in Table C1-1 shall be constructed.

Table C1-1 List of 11kV Feeders from Birauta Substation

Feeder No.	Feeder Name	Overhead or Underground	Approximate Route Length (km)
1	Fewa-N	U/G	1.3
2	Airport-N	U/G	2.6
3	Sahid-Chowk-N	U/G	3.0
4	Fewa-PS	U/G	0.5
5	Fewa-R1	U/G	1.8



		O/H	0.3 (Replacement of Conductor)
6	Fewa-R2	U/G	1.8
		O/H	0.3
7	Fewa-R3	U/G	0.8
8	Fewa-R4	U/G	1.2
		O/H	1.1

The expected route map of 11kV feeders is shown in Drawing No. BIR-DL-0003, and the conceptual single line diagram for Scope of Work is in Drawing No. BIR-DL-0004. 11kV distribution lines on utility poles located within 10 m from the edge of road, shall be undergrounded.

The following works shall be included in the Scope of Work.

- (1) Turnkey construction of MV (11kV) underground distribution lines from Birauta substation to connect to existing distribution lines from Kudhar substation.

The scope of work includes the supply and installation of all necessary equipment, associated civil works and testing and commissioning.

- (2) Turnkey construction of MV (11kV) overhead lines connected to the underground distribution lines for the feeders no. 6 and no.8

These 11kV overhead distribution lines shall be constructed to extend feeders no. 6 and no. 8 and finally to connect to existing 11kV overhead distribution lines as shown in Drawing No. BIR-DL-0004. For the purpose of installation of new distribution lines, replacement of utility poles, installing the brackets, stringing of 11 kV overhead conductor, shifting the existing conductors to newly erected poles, installing stay sets and insulators, and so on are required to fully complete the 11kV distribution lines.

- (3) Installation of Ring Main Units (RMUs) to connect feeding lines to distribution transformers (DTs) and 11kV branch lines.

Turnkey installation of SCADA enabled RMUs with inbuilt Feeder Remote Terminal Unit (FRTU) and Fault Passage Indicator (FPI), the associated civil works, testing and commissioning.

2.2 Undergrounding of low voltage (LV) network on the roads where MV network is to be undergrounded

Scope of Work shall include the turnkey construction of LV underground network which includes installation of LV underground cables, LV feeder panels, service pillars and service cables to the customer's residences.

In the detailed design phase, the Contractor shall clearly mark the details (but not limited to), namely the locations of the existing DTs, the proposed RMUs, LT feeder panel and communication equipment and submit it to the Employer/Engineer for approval.

LV lines and service cables on utility poles located within 10 m from the edge of road, shall be also undergrounded. The service cables shall be installed up to the existing metering units. The list of customers and design of wiring to the customers shall be designed by Contractor and approved by the Engineer/Employer.



A tamper-evident seal shall be installed on the meter terminal cover in the presence of the Employer's representative upon completion of service cable construction work. The meter seals shall be provided by the Employer.

2.3 Installation of SCADA system and communication system for distribution lines for the above 8 MV distribution feeders

Fiber Optic Cables (FOC) and communication system shall be designed, supplied and installed to establish communication network for NEA's SCADA communication system.

Local SCADA system shall be installed in the Birauta substation, and Fiber Optic cables shall be connected to SCADA system in Birauta substation, and erection of the communication system between Birauta Substation and the Distribution Command and Control Center (DCC) in Kathmandu shall be designed, supplied, installed, tested, and completed to achieve proper communication for control and status monitoring of the equipment from / to the DCC as a turnkey contract.

As of 2025, an ADB funded project has been establishing an automation system for distribution line around the Kudhar substation including SCADA system. Considering such a situation, communication system including Local SCADA system shall be designed by the Contractor.

As mentioned in 2.1 (3), the Scope of Work includes installation of SCADA enabled RMUs and G.O Load Break Switch with FRTU and FPI, the associated civil works, testing and commissioning.

2 spare pipes for underground Fiber Optic cables shall be installed for the future use.

2.4 Common Requirements

- (a) Dismantling of existing facilities (if necessary), such as MV overhead line, LV overhead line, streetlight and utility pole, shall be out of scope. However, in case dismantling existing facilities is necessarily required for the construction work, that shall be carried out by the Contractor and transported to any of storage yard of the Employer.
- (b) Any minor electrical/communication equipment/items which are not mentioned in the bidding documents but are required for the successful completion of the project shall be in the scope of Contractor for which no extra payment will be made.
- (c) Liability and Cost of any damages to the existing facilities of NEA and other utilities incurred by the Contractor during the construction process shall be borne by the Contractor.
- (d) Any property belonging to private or public/government (e.g. water pipe, tele communication cable, power cable, sewerage pipe etc.) damaged during construction works shall immediately be restored by the Contractor without any cost to Employer. The liability and cost of the restoration shall be totally scope of work.

3 TERMINAL POINTS

3.1 General

The terminal points of the scope of Distribution Line Work are mentioned in the subsequent sub-clauses. However, the interface of terminal points with the scope of Substation and Transmission Line Work under this project shall be managed by the Contractor to complete the entire Scope of



Work under the Project at their responsibility.

In Pokhara, an ADB-funded project, “Design, Supply, Installation, and Commissioning of Underground Distribution Network under Pokhara and Bharatpur Distribution Center including Reinforcement and Automation” is ongoing, which covers the distribution line improvement from Kudhar (Pokhara) substation.

Some 11kV feeders to be constructed under the Contract will be linked with feeders to be constructed by the ongoing ADB project. A well-considered design with primary 11kV circuit link coordination and feeder system data communication with Master SCADA system shall be required.

The power flows of 11kV feeders from both substations (Kudhar substation and Birauta substation) will be interchangeable after the commencement of operation of Birauta Substation. The design of the feeder protection and condition monitoring shall be coordinated between both substations, and necessary information shall be interchangeable.

3.2 Distribution Line Work in Birauta Substation

The following works are terminal points of Distribution Line Work, which shall be conducted by the Contractor for Distribution Line Work.

(a) 11 kV underground cable connection

Connection of 11 kV underground cables to Circuit Breaker (CB) in substation building

(b) Communication

Installation of Fiber Optic cables in the substation building and connection to Optical Distribution Frame (ODF) and router,

(c) Installation of Remote Terminal Unit (RTU) and Local SCADA System, cable connection to Gateway Device

3.3 Interface with Existing Distribution Facilities

The following works are terminal points for interface with existing distribution lines, which shall be conducted by the Contractor.

(a) Medium Voltage (11 kV) system connection

- Connection to Load Break Switch (LBS) in Ring Main Unit (RMU)
- Connection to existing overhead lines

(b) Low Voltage (400/230V) system connection

- Connection to the secondary side terminal of existing DT (Distribution Transformer)
- Connection to existing overhead lines
- Connection of service cable to Watt Hour meters of the consumers.

(c) Communication

- Connection to Fiber Management System (FMS) in Ring Main Unit



4 SITE ENVIRONMENTAL CONDITIONS

4.1 Metrological and Climate condition

Altitude above sea level:	850 m
Ambient Air Temperature:	0 deg C (minimum) to 45 deg C (maximum)
Average Humidity (in %):	100 (maximum), 40 (minimum)
Wind Load:	Wind Speed Zone 4.
Seismic Requirement for Substations:	0.5 g (Horizontal peak acceleration value).

However, for design purposes, ambient temperature should be considered as 50 degree Celsius and Relative humidity 100%. Altitude (from MSL) to be considered as 1450 meter.

4.2 Electrical condition

Nominal Voltage for Medium voltage	11 kV
Nominal Voltage for Low voltage	400/230V
Frequency	50 Hz
Fault level	25 kA for 3 sec

However, the fault level of equipment, if indicated in respective sections shall prevail for the respective equipment.

5 ELECTRICITY, WATER, GAS, AND OTHER SERVICES

The Contractor shall at his expense, provide all electricity, water, gas, and the other services necessary to execute and complete the works on site.

6 MAJOR EQUIPMENT AND SPARE PARTS

This section covers the only major items, the Bidder is required to ascertain by themselves whether any additional equipment or works are necessary to execute and complete the works in accordance with the Specification and Bid drawings, as a design build contract.

6.1 Power Cable and Fiber Optics (FO) Cable

6.1.1 11kV underground (UG) cable

- Approx. 12.9 km in length of 3-Core, 400 mm², 11 kV XLPE Armoured Aluminium Cable
- Approx. 0.1 km in length of 3-Core, 150 mm², 11 kV XLPE Armoured Aluminium Cable
- Approx. 0.1 km in length of HDPE Pipes 125 mm diameter
- Approx. 12.9 km in length of HDPE Pipes 160 mm diameter
- Approx. 2.0 km in length of GI pipes 150 mm diameter, 5.5 mm thick high grade for road crossing
- Approx. 10 m in length of truss type cable bridge for small river (canal) crossing and the support structure
- Approx. 30 m in length of RCC cable trough (trench) for underground cable rack in the substation premises



6.1.2 11kV overhead (OH) conductor

- Approx. 5.5 km in length of 1-Core, 100 mm², 11 kV XLPE Insulated AAA Conductor

6.1.3 LT underground (UG) cable

- Approx. 0.45 km in length of 3.5 Core, 300 mm², LT XLPE Armoured Aluminium Cable
- Approx. 9.15 km in length of 3.5 Core, 185 mm², LT XLPE Armoured Aluminium Cable
- Approx. 9.15 km in length of HDPE Pipes 125 mm diameter
- Approx. 0.45 km in length of HDPE Pipes 160 mm diameter
- Approx. 0.6 km in length of GI pipes 150 mm diameter, 5.5 mm thick high grade for road crossing

6.1.4 LT Service cable

- Approx. 430 units of 2 Core, 6 mm², LT XLPE Armoured Aluminium Cable with PVC pipes (50 m in length /unit)
- Approx. 90 units of 2 Core, 10 mm², LT XLPE Armoured Aluminium Cable with PVC pipes (50 m in length /units)
- Approx. 30 units of 2 Core, 35 mm², LT XLPE Armoured Aluminium Cable with PVC pipes (50 m in length /units)
- Approx. 30 units of 3 Core, 25+16 mm², LT XLPE Armoured Aluminium Cable with PVC pipes (50 m in length /units)
- Approx. 30 units of 3 Core, 70+35 mm², LT XLPE Armoured Aluminium Cable with PVC pipes (50 m in length /units)

6.1.5 Fiber Optic (FO) cable and the accessories

- Approx. 4.7 km Unarmoured Underground Fiber Optic Cable, 96-Fibers, DWSW
- Approx. 0.2 km Unarmoured Underground Fiber Optic Cable, 24-Fibers, DWSW
- Approx. 14.7 km in length of PLB-HDPE Pipes 40 mm diameter (considering 2 spare pipes)

6.2 Handhole

- Approx. 28 units RCC handholes for optical cable joints and service loops.

6.3 Gang Operated (G.O) Load Break Switch

- Approx. 1 set Outdoor type 11kV G.O. Load Break Switch complete with FPI for Overhead Distribution Line.
- Approx. 1 set Feeder Remote Terminal Unit suitable for above type of G.O Load Break Switch

6.4 Ring Main Unit (RMU)

- Approx. 3 set Outdoor type 11kV SF6 type extensible and motorized 5 way smart Ring Main Unit (RMU) complete with 2VCB and 3 LBS with FPI
- Approx. 3 set Feeder Remote Terminal Unit suitable for above type of RMUs
- MS Galvanized steel supporting base structure for above equipment



6.5 Equipment for Distribution Management System

- 1 unit of Local SCADA system
- 1 unit of Network Management System (software and hardware including MPLS-TP equipment and Remote Terminal Unit)
- 1 unit of Craft Terminal based Network Management System (Laptop)

6.6 LT distribution pillar panel

- Approx. 5 set, 6-way distribution feeder pillar with 1 No MCCB, 4 pole, 3 phase, 415 V, 500 Amps for incoming and 5 Nos outgoing MCCB, 4 poles, 4 phase, 415 V, 200 Amps rating each, along with LT CTs and multifunction metering arrangement on incomer suitable for outdoor installation,
- Approx. 4 set, 6-way distribution feeder pillar with 1 No MCCB, 4 pole, 3 phase, 415 V, 400 Amps for incoming and 5 nos outgoing MCCB, 4 poles, 4 phase, 415 V, 200 Amps rating each, along with LT CTs and multifunction metering arrangement on incomer suitable for outdoor installation,
- Approx. 42 set, 5- Way distribution feeder pillar with 5 Nos outgoing MCCB 4 Pole, 3 phase 415 v, 200 Amps rating each suitable for outdoor installation
- Approx. 60 set, 3 phase, 4 pole ,415 V, distribution service pillar for LT, 150 Amps incoming MCCB: 1 np. With business for upto 30 connection distribution service pillar suitable for outdoor installation
- MS galvanized steel supporting base structure for above equipment

6.7 Utility Pole and the accessories

- Approx. 20 set, Steel Tubular Pole 11.0 m long
- Approx. 10 set, Steel Tubular Pole 13.0 m long
- 2 set, Supporting Structures, the foundation work and piling work if necessary for river crossing
- Installation of brackets, stay wire sets, insulators, clamps and earthing

6.8 Mandatory Spare Parts and Recommended Spare Parts

Bidder shall estimate the prices for the items of mandatory spare parts in Schedule No.6, meanwhile shall list and price the recommended spare parts in Schedule No.7 of the Price Schedule.

7 TRAINING

7.1 Training at Factory

The overseas training required in the Contract is given below, while the field/local training shall be carried out at the overseas manufacturer's shop.

The cost of transportation (international air ticket and inland transportation), accommodation, meals and incidental expenses for overseas training such as VISA cost, daily allowance (USD 70 per day), etc. shall be borne by the Contractor.

Training Item : MPLS equipment

Training outline :

- (a) Duration of training: Seven (7) days for two (2) engineers including travel days



- (b) Number of trainees from the Employer: Two (2) engineers relating to operation and maintenance
- (c) Training Program: general design, operation and maintenance of Equipment of MPLS equipment which shall be proposed by the Contractor subject to approval by the Engineer
- (d) Place of training: Overseas manufacturer's factory

7.2 Training at Site

The training at site required in the Contract is given below, while the other field/local trainings shall be carried out as per the relevant clauses in the Specification.

The Contractor shall be responsible for providing suitable technical trainings for the Employer's staff/engineers at the site on the Plant for the following items:

- RMU
- FRTU
- MPLS Equipment

The Contractor shall train the Employer's staff to enable them to sustain their proper operation and maintenance of those Plant, and the training program shall be subject to the Engineer's approval. The cost of training including preparation of training texts, and dispatching the appropriate trainees from each manufacturer shall be quoted in the Price Schedule.

8 FACTORY ACCEPTANCE TEST (FAT) WITNESSED BY THE EMPLOYER AND THE ENGINEER

The Contractor shall arrange for the Employer and the Engineer's representatives to witness tests on the following items at the manufacturer's shops:

- RMU (Ring Main Unit)
- XLPE Power Cable
- HDPE Pipe

For FAT for each item, two (2) inspectors from the Employer will attend the factory inspection. The cost of transportation (international air ticket and inland transportation), accommodation, meals and incidental expenses for the Employer's representative such as VISA cost, daily allowance (USD 100 per day), etc. for the period of seven (7) days (including the travel days) shall be included in the Contract Price. The detail requirement shall be referred to the Chapter 22.



PART – 2C:

EMPLOYER’S REQUIREMENTS FOR

DISTRIBUTION LINE WORK

SECTION VI.C2: TECHNICAL SPECIFICATION



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SECTION VI.C2: TECHNICAL SPECIFICATION

CONTENTS

CHAPTER 1	GENERAL REQUIREMENTS
CHAPTER 2	POWER CABLES FOR UNDERGROUND
CHAPTER 3	OVERHEAD CONDUCTOR AND CABLE
CHAPTER 4	CONDUITS, TRENCH AND MANHOLE
CHAPTER 5	RING MAIN UNIT (RMU)
CHAPTER 6	LT PANEL
CHAPTER 7	UTILITY POLE (STEEL TUBULAR POLE)
CHAPTER 8	PORCELAIN INSULATORS AND FITTINGS
CHAPTER 9	GANG OPERATED LOAD BREAK SWITCH
CHAPTER 10	LIGHTNING ARRESTER
CHAPTER 11	STEEL LATTICE TOWERS
CHAPTER 12	MISCELLANEOUS ITEM FOR OVERHEAD LINE
CHAPTER 13	DATA COMMUNICATION SYSTEM
CHAPTER 14	NETWORK CONFIGURATION AND EQUIPMENT
CHAPTER 15	REMOTE TERMINAL UNIT (RTU)
CHAPTER 16	FEEDER REMOTE TERMINAL UNIT (FRTU)
CHAPTER 17	SDH, MPLS SWITCHABLE OPTICAL TERMINAL
CHAPTER 18	UNDERGROUND FIBER OPTIC (UGFO) CABLE
CHAPTER 19	FMS, FODP AND SPLICE ENCLOSURE



CHAPTER 20	METERING ARRANGEMENT
CHAPTER 21	CIVIL WORKS
CHAPTER 22	INSPECTION AND TESTING
CHAPTER 23	DESIGN REQUIREMENTS FOR RIVER CROSSING
CHAPTER 24	SAFETY SPECIFICATION
CHAPTER 25	SOCIAL AND ENVIRONMENTAL REQUIREMENTS



CHAPTER 1:

GENERAL REQUIREMENTS



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CHAPTER 1: GENERAL REQUIREMENTS

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
1.1	General	1
1.1.1	Extent of Contract	1
1.1.2	General Design of Equipment	1
1.1.3	Quality Assurance	2
1.1.4	Units of measurement	3
1.1.5	Compliance with specification	3
1.1.6	Contractor's Documents	3
1.1.7	As-Built Documents	7
1.1.8	Access to Site	8
1.1.9	Packing	8
1.1.10	General Cleaning and Preparation	9
1.1.11	Tropicalization	10
1.1.12	Tools and Equipment	10
1.1.13	Special Tools and Tackles	11
1.1.14	Installation, Operation and Maintenance Instructions	11
1.1.15	Inventory Records for Plants and Materials	12
1.1.16	Language	12
1.1.17	Procedure for Delivery of Documentation	12
1.1.18	Approval Procedure	14
1.2	MECHANICAL Design Criteria	15
1.2.1	Nuts, Bolts, Studs and Washer	15
1.2.2	Welding	15
1.2.3	Chromium Plating	16
1.2.4	Hot dip Galvanizing	16
1.2.5	Painting	16
1.2.6	Rubbers	17
1.2.7	Rivet	17
1.2.8	Forging	17
1.2.9	Casting	17
1.3	ELECTRICAL DESIGN CRITERIA	17
1.3.1	System Condition and withstand level	17
1.3.2	Creepage distance	18
1.3.3	Anti-condensation heater	18
1.4	TECHNICAL STANDARDS	18



1.4.1	General Technical Specification	18
1.4.2	Circuit Breakers	19
1.4.3	Current Transformers, Voltage Transformers	19
1.4.4	Surge Arresters	19
1.4.5	Cubicles and Panels & Other Related Equipment	19
1.4.6	Disconnecting Switches / Load Break Switch	20
1.4.7	Protection and control equipment	20
1.4.8	Motors	21
1.4.9	Electronic Equipment and Components	21
1.4.10	Material and workmanship standards	21
1.4.11	Clamps and Connector	21
1.4.12	Batteries and Battery Charger	22
1.4.13	Wires and Cables	22
1.4.14	Paintings	23
1.4.15	Piping Valves & Specialities	23
1.4.16	Steel structures	23
1.5	Protection of Environment	24
1.5.1	Transportation	24
1.5.2	The Adherence to the Environmental Acts, Regulations and / or Guidelines	24
1.6	Contractor's responsibility	26
1.6.1	Safety of Personnel	26
1.6.2	Contractor's Employees	26
1.6.3	Contractor's Key personnel	27
1.6.4	Progress Report	27
1.6.5	Progress Meeting	27
1.6.6	Material Storage	27
1.6.7	Site Sign Boards	28



1.1 GENERAL

1.1.1 Extent of Contract

This Contract is on a turnkey basis & includes the site survey, design, manufacture, inspecting and testing, insurance, packing for export, shipment, clearing from port, delivery to site, unloading, complete erection, finishing, painting, site testing, training and commissioning of the equipment described herein.

The Contractor shall be responsible for making good for any defective material design or workmanship for a period of twelve months after taking over as Defect Notification Period.

The Contractor is to co-operate with other Contractors and NEA operating staff as may be necessary.

The Contractor is responsible for design, supplying and erecting all plant such that the complete function is guaranteed, without necessity for any additional works to be initiated by the Engineer, unless specifically excluded in these Bidding Documents or agreed upon in writing. That includes among others e.g.: protection and other studies, manufacture, type tests, testing at factory and at site, insurance, packing, transportation and delivery to site, erection and commissioning.

Works must fully interact with each other in every respect. Additionally, they must properly interact with any other Contractor's work as far as an interfacing is specified or mentioned herein.

In case the Contractor finds any parts of these Specifications incomplete, contradictory or defective, he shall be responsible to immediately bring this to the notice of the Employer and make a proposal for the Employer's approval, for making good such incompleteness or defect at the stage of bidding. No additional cost to the Employer shall arise out of such rectification.

If the Contractor requires to obtain a third party opinion with regard to the content of this specification during the design or construction stage, the Contractor shall obtain prior approval from the Employer to seek the third party consultation.

Main design data given in these Specifications and general drawings are available in the Bid Drawings.

1.1.2 General Design of Equipment

In complying with the requirements of the specification, design shall conform to the best current engineering practice. Each component part of the Plant shall be to the maker's standard design provided that this design is in general accordance with the Specification.

All equipment and materials shall be in accordance with the International Electrotechnical Commission (IEC) standards, International Standardization Organization (ISO) standards or standards especially indicated in the respective sections.

The issues of standards valid for the contract shall be the latest issues (including amendments) current at the Bid closing date.

It is not the intent to specify completely herein all the details of design and manufacturing of the cables and accessories. It may be noted that norms, standards etc. specified are the bare minimum that is required. The cables and their accessories shall conform to highest standards of engineering design and workman ship and shall be capable of performing continuous commercial operation within the parameters, guaranteed by the supplier in a manner acceptable to the Engineer.



Whenever in these specifications the requirements are more preferable than those in the standards, these specifications represent an additional requirement above that of the standard.

The essence of design shall be simplicity and reliability in order to give long continuous service with high economy and low maintenance costs.

Particular attention shall be paid to internal and external access in order to facilitate inspection, cleaning and maintenance.

The design, dimensions and materials of all parts are to be such that they will not suffer damage as a result of stresses under the most severe service conditions.

Full detailed specifications of the component parts of the plant are to be submitted describing particularly the materials to be used.

Works shown upon the drawings and not mentioned or described in the specification and works described in the specification and not shown on the drawing will nevertheless be held to be included in this contract and their execution shall be covered by the contract price in the same manner as if they have been expressly shown upon the drawings and described in the specification.

The materials used in the construction of the plant shall be of the highest quality and selected particularly to meet the duties required to them. Mechanisms shall be constructed to avoid sticking due to rust or corrosion. Workmanship and general finish shall be of the highest quality throughout. All similar parts of the plant shall be interchangeable. All apparatus shall operate without under vibration and with the least practicable amount of noise. All equipment shall be designed to minimize the risk of fire and any damage, which may be caused in the event of fire, shall be as minimal as possible. All apparatus shall be designed to prevent the risk of accidental short circuit, malfunction or damage due to vermin. All items of equipment, which may have to be lifted for erection or maintenance, shall be provided with lifting eyes, jacking pads or alternative handling facilities.

The Contractor shall also abide by the project procedure mentioned in the General Conditions and Particular Conditions or otherwise to be agreed during the kick off meeting among the Contractor, Employer, and Engineer, which includes the project organization, details the form and handling of correspondence and documents including a numbering system, procedures for meetings and document approval, gives some guidelines on quality assurance, time scheduling, progress monitoring and so on. The Contractor shall assign all the personnel who are nominated in the Technical Bid, and all the positions with nominated personnel shall be listed in the project organization. When the Contractor needs to replace the personnel, the replacement shall have an equivalent or more experience than original personnel subject to approval of the Engineer.

1.1.3 Quality Assurance

The quality of the design, manufacturing and erection processes shall be assured by the Contractor in accordance with the ISO 9000 series standards. The Contractor shall provide his possession of the respective certificates.

The Bidder shall prove that the quality of the design, manufacturing and erection would be done in accordance with ISO 9001. The Bidder shall submit respective certificates issued by an International Organization at least for the equivalent list below.

- (i) 11kV 3-Core XLPE Armoured Aluminum Power Cable
- (ii) 11kV XLPE Insulated All Aluminum Alloy Conductor



- (iii) LT XLPE Armoured 3.5-Core Aluminum Power Cable
- (iv) LT Service Cable
- (v) Fiber Optics Cables & accessories
- (vi) 11 kV Ring Main Unit (RMU) and the equipment inside
- (vii) Gang Operated (G.O.) Load Break Switch
- (viii) Lightning Arrestor
- (ix) Porcelain Insulator
- (x) LT Distribution Pillar, Distribution Service Pillar and the equipment inside
- (xi) Galvanized Steel Tubular Pole
- (xii) RTU, FRTU
- (xiii) SCADA/DMS (hardware and software)
- (xiv) SDH/MPLS-TP equipment
- (xv) Metering, Protection & Control equipment

1.1.4 Units of measurement

In all correspondence, in all technical schedules and on all drawings metric systems International Units (SI) units shall be used. On drawings where imperial or other units have been used it will be in order if the equipment SI units are suitably marked in addition.

1.1.5 Compliance with specification

Notwithstanding any descriptions, drawings or illustrations which may have been submitted with the Bidder, all details other than those shown on the schedule of departures will be deemed to be in accordance with the Specification and the standard specifications and codes referred to therein.

All exceptions shall be clarified and separately itemized. It shall not be necessary for the Employer to examine the standard literature and documents of the manufacturer to determine the existence and extent of any exceptions or deviations from specification.

1.1.6 Contractor's Documents

(1) General

Before the work is put in hand, five (5) hard-copies of general drawings and diagrams showing all details of the Plant and Materials shall be submitted to the Employer and the Engineer for approval. In addition, soft copy in pdf format shall be uploaded to a cloud server to share with the Employer and the Engineer for the purpose of smooth operation. The cost of cloud server operation is deemed to be included in the Contract Price, and the Contractor's documents for all approval status and the Engineer's comments on the Contractor's documents shall well be maintained in the cloud server by the Contractor throughout the Contract period.

Detailed drawings shall be submitted in five (5) copies as soon as possible after the Commencement Date and in any case in sufficient time to permit modifications to be made, if such are deemed necessary by the Engineer, without delaying the delivery of the contract work. The



drawings submitted shall be modified as requested by the Engineer and re-submitted for approval if required.

Prior to the commencement of construction/erection work, the Contractor shall distribute copies of the approved drawings and documents (for work drawings) as directed by the Engineer, to the Employer in two (2) sets and to the Engineer in two (2) sets. In addition, soft copy in pdf format shall be uploaded in the cloud server to share with the Employer and the Engineer for the purpose of smooth operation.

Any documentation submitted by the Contractor for approval shall only be in sizes A2, A3 or A4 (210 x 297mm), preferably A3 and A4. A2 shall only be used if absolutely necessary. All drawings shall be prepared using the Computer Aided Drafting (CAD).

The following documentation shall definitely be included in the documents to be submitted by the Contractor for approval by the Engineer before construction or erection of the respective part of the works may start.

Category	Documents Required
Electrical Drawings	Single line diagrams for MV, LV circuits
	Low voltage circuit diagrams
	DC voltage circuit diagrams
Layout and Arrangement	MV line location Map Whole Project
	MV line location Map per Feeder
	LV line location Map per Feeder
	LT Pillar location Map per Distribution Transformer
	Detailed RMU installation layout of all RMU
	Detailed Low Tension Pillar installation layout of all LT pillar
	Drawings of all other equipment arrangement
Protection and Circuit Diagrams	Functional block diagrams for protection of RMU
	Complete circuit diagrams of RMU
	Complete circuit diagrams of RTU
Scheduling	Detailed construction schedule in the form of a bar chart
Cabling	Cable laying diagram and schedule
RMU Station Design	RMU Station Design Criteria
Earthing Design	RMU and Low Tension Pillar Earthing layout
Civil Design for Overhead line	Codes and standards to be adopted in the design
	Loading for structural elements
	Load factors and combinations
	Design methods and theories
	Base structural calculations and general arrangement drawings
	Architectural scheme design and detailed drawings (plans, elevations, sections)
	Finishing schedules
Civil Design for Underground line	Structural detail drawings
	Codes and standards to be adopted in the design
	Loading for structural elements
	Load factors and combinations
	Design methods and theories
	Base structural calculations and general arrangement drawings
	Architectural scheme design and detailed drawings (plans, elevations, sections)
Civil Design for Overhead line	Finishing schedules
	Structural detail drawings



including Towers at the river crossing point	Loading for structural elements
	Load factors and combinations
	Design methods and theories
	Base structural calculations and general arrangement drawings
	Architectural scheme design and detailed drawings (plans, elevations, sections)
	Finishing schedules
	Structural detail drawings
Civil Design for MV Cable Bridge at Birauta Chowk	Codes and standards to be adopted in the design
	Loading for structural elements
	Load factors and combinations
	Design methods and theories
	Base structural calculations and general arrangement drawings
	Architectural scheme design and detailed drawings (plans, elevations, sections)
	Finishing schedules
Civil Design for RMU foundation	Codes and standards to be adopted in the design
	Loading for structural elements
	Load factors and combinations
	Design methods and theories
	Base structural calculations and general arrangement drawings
	Architectural scheme design and detailed drawings (plans, elevations, sections)
	Staircase details (if applicable)
Civil Design for Low Tension Pillar Foundation	Codes and standards to be adopted in the design
	Loading for structural elements
	Load factors and combinations
	Design methods and theories
	Base structural calculations and general arrangement drawings
	Architectural scheme design and detailed drawings (plans, elevations, sections)
	Finishing schedules
	Structural detail drawings

The Contractor shall submit a Master List with the Programme, which is complete list of all drawings listing the drawing number and title, together with the date that the drawing is planned to be submitted for approval and the date it is required on site. In the same list, the actual dates of submission of each revision as well as date and status of approval. The Contractor shall update the list at monthly interval.

The Engineer's review of documents / drawings submitted by Contractor for approval shall generally not exceed 24 working days of the Employer, calculated from the date on which the Engineer receives Contractor's documents / drawings and Contractor's notice in writing. If the Contractor needs urgent approval on parts of documents / drawings, he may request the Engineer time to time.

The Employer's approval does not in any way relieve the Contractor of his full responsibility for the correctness of his documentation and the proper functioning, quality and compliance with the Specifications of all plant and equipment supplied by him. The Employer's approval shall not relieve the Contractor from full responsibility from mistakes or omissions therein or therefrom (including any resultant mistake or error in the Works) or for any discrepancy or deviation from the technical



specifications and other drawings.

After all items of plant have been manufactured and erected, data file on Auto CAD format or reproducible digitized drawing file, of each drawing previously approved shall be provided together with four prints on heavy gauge white paper from such drawings as may be required to show the detailed and arrangement of the plant as made and installed.

All drawings submitted by the Contractor or by any sub-Contractor shall have the following particulars in the lower right hand corner in addition to the Contractor's name, date, scale, number and title of the drawings.

Project Name	URBAN TRANSMISSION AND DISTRIBUTION SYSTEM IMPROVEMENT PROJECT
Employer	NEPAL ELECTRICITY AUTHORITY
Description of Apparatus	
Contract No.	
Engineer's Serial No.	

The Engineer's serial no. shall be inserted by the Contractor before submission of the drawing. The serial number and index system, detailed below will be agreed at the kick off meeting between the Contractor and the Engineer.

The Contractor shall when submitting drawings provide an indexing system for all the drawings.

The index shall contain the following information for each drawing.

- (i) Drawing number
- (ii) Revision
- (iii) Engineer's serial number
- (iv) Title
- (v) Date submitted for approval
- (vi) Date returned for correction
- (vii) Date approved for construction
- (viii) Date final drawings submitted
- (ix) Number of Copies
- (x) Remarks/Distribution Column for use by the Engineer

The Contractor shall keep on site accurate and up to date drawings and records and shall provide the Engineer with one set of copy each. At the end of every week the Contractor shall submit to the Engineer schedules of labor, plant and materials employed on the site during that week.

During site test and commissioning, if there is any correction on the drawing, the Contractor shall inform the Employer/Engineer and take approval from the Engineer.

All documentation including final designs & drawings approved by the Engineer and any documents used during erection or commissioning with approved status of the Engineer shall be updated at the end of the commissioning period to show the as built status.

This updating and modifications shall be clearly indicated in red color for easy reference. Three (3) sets of complete drawings at least shall be prepared under the responsibility of the Contractor's



chief commissioning engineer. Two sets shall remain with the Employer/Engineer while the other set is sent to the Contractor's office where all modifications will be included in new neat As Built documents which shall be distributed to the Employer and to the Engineer.

From the beginning of site work the Contractor shall keep on providing photographs of the works, from positions to be selected by Employer/Engineer, at monthly intervals.

The soft copy of all photographs shall be uploaded in the cloud server, numbered and handed over to Employer/Engineer on completion of the Contract with As Build documents.

The Contractor shall provide a number of selected photographs for submission with the Monthly Progress Report as required by Employer/Engineer. The Contractor shall provide additional photographs of the Contract Works to record or illustrate specific events at the request of Employer/Engineer.

(2) Type of Documents

The Contractor shall submit the number of hard copy of Documents as specified in each Section. The Contractor shall establish a cloud server at his expense, and soft copy of Documents and all submittals shall be uploaded in the cloud server. Authorization of access and control shall be managed by the Contractor, and the number of authorized personnel shall be minimized.

1.1.7 As-Built Documents

(1) General

AS BUILT documents shall be submitted to the Employer in five (5) sets and to the Engineer in one (1) set in accordance with GC Clause 5.6. In addition, the soft copy of AS BUILT documents in PDF format and Auto-CAD/excel/word (editable soft copy) shall be uploaded in the cloud server.

The supply of AS BUILT documents shall comprise but not be limited to all drawings for construction and installation, calculations, instructions for operation, maintenance, repair and adjustment, apparatus lists, spare parts lists containing information needed for ordering for all equipment supplied under the Contract.

(2) Plant Design Documents

The following documents shall be delivered.

- (a) All layout, diagrams, construction and installation drawings.
- (b) All calculations regarding civil, electrical and mechanical design for all Plants.

(3) Apparatus Documentation

Documents for approval shall be delivered before the work is started but shall also be included in the AS BUILT documents as follows.

- (a) Type test reports and certificates for important equipment. Data Specifications on other equipment.
- (b) Routine test reports and certificates.
- (c) Data lists with by the Employer/Engineer required amendments incorporated. The contents of the lists shall correspond to the schedules of this document. Data lists will be regarded as binding for the manufacturer.
- (d) Dimension drawings. They shall be regarded as binding for the manufacturer and shall contain



measures, weights and features of the apparatus.

(e) Detail drawings as required by the Employer.

1.1.8 Access to Site

The Contractor shall make his own arrangements for handling and transport and off loading at site so as no facilities being available for him. Plant will generally be delivered to the sites by road. The Contractor is to make his own enquiry as to the suitability, availability and charges for railway cranes, suitability of available wagons for the transport of any loads and any restrictions imposed by clearance gauges. The highways, road and bridges have widely varying load limits, and the Contractor shall be responsible for determining the load limits existing at the time and ensuring that his plant does not exceed such limits.

The Contractor shall be deemed to have included in his costs any temporary measures necessary to allow the transport of the plant over existing roads and bridges.

Before moving any heavy traffic on to highway, road and bridges, the Contractor shall make suitable arrangements with the appropriate government authorities and obtain their approval for the passage of such traffic.

In the event that any permanent reinforcement of road and bridges may be considered necessary for transport of the plant, the Bidder shall obtain an estimate of the costs from the Government department concerned and include this as a provisional sum in the schedule of price.

The Contractor shall not use tracked vehicles or plant on any bituminous sealed road surface. Rubber tiered vehicles conforming to applicable load restrictions will be permitted to use bituminous sealed roads.

It shall be the Contractor's responsibility to ascertain the availability in Nepal of suitable transport vehicle for the plant and arrange for the provision of such vehicles as may be necessary.

Within the site areas, the Employer will maintain existing roads and the Contractor will be given use of the roads essential to his operations free of charge for normal traffic. Any damage caused by the Contractor's abnormal traffic shall be repaired at his own expense.

The Contractor shall take into account the fact that the Grid Substations are high security areas, where access is strictly controlled. The Contractor shall follow all security procedures adapted at these installations.

1.1.9 Packing

Each item of plant shall be packed properly and protected for shipment and transport from the place of manufacturer to site and in addition for storage for a minimum of three months under the site climate conditions. The recommendations of the BS1133 Packaging code or equivalent international standard shall be observed with particular reference.

Tube ends and other similar open ends shall be protected from both, external damage and ingress of dirt and moisture during transit and while awaiting erection at site. Flanged pipes shall have their open ends protected by adhesive tape or jointing and then be covered with a wooden blank flange secured by service bolts.

Precautions shall be taken to protect shaft and journals where they rest on wooden or other supports likely to contain moisture. At such points, wrappings impregnated with anti-rust composition or vapor phase inhibitors shall be used of sufficient strength to resist chafing and indentation due to



movement, which is likely to occur in transit. Protective wrappings and impregnation shall be suitable for a period of three months.

In the case of ball or roller bearing installed in any item of plant, precautions shall be taken to avoid indentation of the bearing races. Metal bindings of cases shall be of corrosion resistant material and shall be properly tightened and the ends crimped together by means of a purpose made tool.

Precautions shall be taken to protect shafts and journals where they rest on wooden or other supports like to contain moisture. At such points, wrappings impregnated with anti-rust composition or vapor phase inhibitors shall be used of sufficient strength to resist chafing and indentation due to movement, which is likely to occur in transit. Protective wrappings and impregnation shall be suitable for a period of three months.

In the case of ball or roller bearings installed in any item of plant, precautions shall be taken to avoid indentation of the bearing races.

Metal binding of cases shall be of corrosion resistant material and shall be properly tightened and the ends crimped together by means of a purpose made tool.

Contents of cases shall be bolted securely or fastened in position with struts or cross battens preferably supported by cleats fixed to the case so that there shall be no movement.

Where parts are required to be bolted to the sides of the case, large washers are to be used to distribute the pressure, and the timber shall be strengthened by means of a pad.

Where practicable, all indoor item such as electric motors, switch and control gear, instruments and panels, machine components, etc., shall be cocooned or covered polyethylene sheeting, sealed at the joints and the enclosure provided internally with desiccators.

All delicate equipment e.g., relays and instrument shall be removed from panels and packed separately for transport in the same consignment as the associated panels. The packing shall contain all equipment destined for the same location.

Where transformers or similar devices are shipped under oil, the oil level shall be above the core and the windings and a silica gel breather shall be fixed to the tank cover or pipe work for protection against moisture entry during transport.

Each crate or package shall contain a packing list in a waterproof envelope. All items of material are to be clearly marked for easy identification against the packing list.

All cases, packages, etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating to them to the appropriate shipping documents. Stencil marks on the outside of casings shall be indelible.

The Engineer may be required to inspect and approve the packing before the items are dispatched but the Contractor shall be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the Contractor from a loss or damage due to faulty packing.

1.1.10 General Cleaning and Preparation

All bright metal parts must be covered with an approved protective compound before shipment and adequately protected during transit. After erection, these parts should be cleaned and polished as required.



Before testing, steel pipes must be thoroughly cleaned by an approved process. Protective coatings are to be applied after testing.

Pipes, valves, and other parts subject to hydraulic testing that are not easily accessible for drying must be washed with approved de-watering oil after testing and before shipment.

All surfaces should be prepared before coating in accordance with relevant ISO standards (ISO 1456, ISO 1458, or others as applicable).

1.1.11 Tropicalization

In choosing materials and their finishes, due regard shall be given to the design considering humid tropical conditions, and the recommendations of British Standard Code of Practice 1014 or equivalent IEC/ISO should be observed unless otherwise approved. Some relaxation of the provisions mentioned above may be permitted where equipment is hermetically sealed, but it is preferred that tropical grade materials should be used wherever possible:

(1) Metals:

Iron and steel are generally to be painted or galvanized as appropriate. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting.

(2) Screws, Nuts, Springs, etc.:

The use of iron and steel is to be avoided in instruments and electrical relays wherever possible. Steel screws are to be zinc, cadmium or chromium plated, or when plating is not possible owing to tolerance limitations, are to be of corrosion-resisting steel. Instrument screws (except those forming part of a magnetic circuit) are to be brass or bronze. Springs are to be of non-rusting material, e.g., phosphor bronze or nickel silver, as far as possible.

(3) Rubbers:

Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc. The rubber material must not produce any corrosive or resting gases.

1.1.12 Tools and Equipment

The Contractor shall have owned, leased or hired tools and equipment for successful execution of the work. Prior to beginning of the work, the Contractor shall show these items in his possession. In case of the heavy tools, equipment and vehicles the Contractor is required to submit the source of these items with credible documents such as contract papers conforming their availability at the time of the execution of the works.

The Employer shall examine to verify the availability of all such tools and equipment before commencement of the work. The Contractor shall be allowed to start his work only after verification of such tools and equipment in satisfaction to the Employer. No tools and equipment shall be provided by the Employer.

The Contractor shall have following tools and equipment for the execution of the Contract (but not limited to):



SN	Description of Tools and Equipment
1	Crane Truck (Minimum 3 Ton lifting capacity)
2	General Purpose Truck (Minimum 10 Ton capacity)
3	Max or Ratchet Puller suitable for HV/LV Cable Tensioning
4	Come along Clamp suitable for HV/LV Cable Tensioning
5	Crimping Device for jointing Cables
6	Cable Pulling, Cable Laying Equipment
7	Winches, Cable rollers
8	Mini Excavator
9	Ground Penetration Radar
10	Horizontal Directional Drilling Machine

1.1.13 Special Tools and Tackles

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. However, a list of all such devices should be indicated in the relevant schedule provided in the Price Schedule. As an exception, the following equipment shall be provided by the Employer.

- 1 set of Digital Multimeter
- 1 set of Ethernet Tester (with Triple port, 10/100/1000 ports Mbps Ethernet Option, Layer 1 & Layer 2 functionality)

In addition to this, the Contractor shall also 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 equipment. 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.

1.1.14 Installation, Operation and Maintenance Instructions

When the general arrangements and details of the plant have been finalized and not later than the erection commences, the Contractor shall submit to the Engineer for approval fully detailed installation instructions. The details shall cover the main plant and all associated ancillary equipment as supplied under the Contract. It will not be sufficient to incorporate manufacturer's standard brochures as part of the text unless they refer particularly to the equipment supplied and are free of extraneous matter. The information provided shall include essential circuit diagrams, general arrangement and detailed drawings of the installation make mention of special materials, erection apparatus and tools where used and include schedules of lubricants and all ball and roller races employed on the plant. The drawings and diagrams, which may be approved existing drawings reduced to a convenient size, shall be bound into the volume and not inserted into cover pockets. List of contract record drawings shall be included.

If the complete text is unduly bulky, then the manual is to be appropriately sub-divided and produced in multi-volume form. When approved, four copies of the complete text, diagrams and drawings as made up in draft form are to be handed to the Engineer for distribution at site and these are to be provided not later than the erection commences.

Further four copies shall be reproduced as a book or books of approximately A4 size and bound



into durable covers inscribed in permanent form upon the front generally in the form of the title page to this document except that the references to Specification, Drawings, etc., will be replaced by the Operating and Maintenance Instructions. In addition, the soft copy in PDF format shall be uploaded in the cloud server.

The original Operating and Maintenance Instructions should be handed over according to Clause 6.6 of the General Conditions of FIDIC. Four additional copies should be reproduced as A4-sized books, bound in durable covers, and inscribed with the relevant details (including the name of the main Contractor, Sub-Contractor, Employer, substation, plant classification, and volume number if applicable).

The name of main Contractor and that of any sub-Contractor shall also be inscribed upon the cover after the description of the plant. The name of the Employer and substation or other identification followed by a classification of the plant shall be inscribed upon the spine of the cover and, if the instructions are contained in several books, these are to be marked with the appropriate volume number.

1.1.15 Inventory Records for Plants and Materials

The Contractor shall forward his inventory records for plant and material at the end of each month to the Employer.

1.1.16 Language

The English language shall be used on all contract documentation and in all correspondence between the Contractor and the Employer.

1.1.17 Procedure for Delivery of Documentation

The Contractor shall submit the following documentation/information to Employer/Engineer for review and approval.

- (1) Within 21 days after the Commencement Date of the Contract
 - (a) Detailed project specific Quality Plans and associated procedures.
- (2) Within 30 days after the Commencement Date of the Contract
 - (a) Detailed contract program containing design, approval of design, ordering of materials, manufacture, shop testing, delivery, civil construction, erection, site testing and commissioning.
 - (b) Detailed list of documentation submittals with documentation classification plan.
 - (c) Detailed breakdown of the Contract Price into Cost Items.
 - (d) Detailed proposal of the Monthly Progress Report format.
 - (e) Contractor's safety and security program.
- (3) Within 60 days after the Commencement Date of the Contract
 - (a) A program of performance, material and workshop test to be carried out.
 - (b) Particulars about presentation and form to be used for the test program shall be agreed and approved by Employer/Engineer.
- (4) Within 90 days after the Commencement Date of the Contract
 - (a) One set of all applicable standards / codes / specifications, etc.



- (b) Copies of all orders placed with Subcontractors.
 - (c) Safety program.
 - (d) Outline drawings of the equipment.
 - (e) Loading of foundations for all items of equipment to be supplied, and details of anchoring and supporting.
 - (f) Delivery of all drawings related to civil works.
 - (g) Preliminary drawings and schemes of connections to the parts supplied under other contracts.
 - (h) Preliminary assembly drawings of the equipment with details of material intended to be used (if applicable).
 - (i) Electrical single line diagrams and Location Map for MV lines, LV lines
 - (j) Location map for RMUs and LT pillars
 - (k) Detailed information (type, make, formula) of products
 - (l) Detailed training program.
- (5) Before commencement of site works
- (a) Approved construction Drawings/Document
- (6) Before beginning of manufacture
- (a) Detailed manufacture drawings/documentation and software designs with all important technical data, final assembly drawings, control schemes, block and circuit diagrams and giving full information about principle of operation, cabling and wiring diagrams.
- (7) During manufacture
- (a) Monthly progress reports,
 - (b) Notice of material tests and shop inspections,
 - (c) Certificate of inspections,
 - (d) Certificate of tests,
 - (e) Information concerning delays, claims, etc.
- (8) At least 30 days before Shipment
- (a) Notice to Employer giving identification, symbol, description, weight and dimensions of material in shipment.
 - (b) Bill of lading for each consignment just prior shipment.
 - (c) Instructions for loading, unloading, handling and special precautions to be observed for storage at Site.
- (9) At least 90 days before commencement of erection
- (a) Erection instructions for approval.
 - (b) Method statement of installation works for approval
 - (c) Approved erection instructions.
 - (d) Complete sets of approved drawings.



- (e) Detailed erection programme for each component for approval.
- (f) Site testing and inspection programme during and at the end of erection for approval.
- (g) Site test procedure for approval
- (10) At least 30 days before commencement of erection
 - (a) Three (3) copies of Certificates of Policy of Insurance related to the site works.
- (11) During erection
 - (a) Monthly Progress Report
 - (b) Weekly Program
- (12) 90 days prior to Taking Over Certificates of equipment/facilities
 - (a) Operating and Maintenance Instructions for approval.
- (13) 90 days before commencement of commissioning
 - (a) Detailed programme and site test proposal (commissioning tests) for each section.
- (14) Before Taking Over
 - (a) Spare parts storage instructions
 - (b) Final commissioning report
 - (c) Final operating and maintenance instructions
 - (d) "As-built" drawings, soft copy of as-built documentation.
- (15) Within 15 days after any occurrence
 - (a) Report on any damage/accident (the first brief report on the occurrence on any damage/accident shall be submitted not later than within 24 hours).
 - (b) Any error discovered by the Contractor in his own design.
 - (c) Test certificates or test reports unless otherwise agreed upon.
 - (d) Any failure of material and equipment.
 - (e) Any delays against schedules.

The durations and time schedule can be negotiated at the kick-off meeting.

1.1.18 Approval Procedure

(1) Number of Copies Required

Five (5) copies of each drawing/documentation shall be submitted by the Contractor to Employer/Engineer for the approval/re-approval and construction purposes.

One (1) copy will be returned to the Contractor marked "Approved", "Approved with Comments", "Return for correction" or "Not Approved" with comments made either on the drawing itself or in the accompanying letter, and the drawing/documentation shall be amended and resubmitted for approval, clearly identifying the amendments.

(2) Review and Approval of Documents



The Contractor shall ensure that all documentation for approval are forwarded to the Employer/Engineer in sufficient time. The Contractor shall also ensure that documentation are submitted at least four weeks prior to the date required for approval to permit amendments to be made and the drawings re-submitted for approval without delaying the programmed deliveries or the guaranteed completion dates of the works.

Drawings marked "Approved" and "Approved with Comments" authorize the Contractor to proceed with construction or fabrication of equipment covered by such drawings with corrections, if any, indicated thereon. Approved drawings must be available before any equipment is workshop tested or before any erection/construction work has started at Site.

1.2 MECHANICAL DESIGN CRITERIA

1.2.1 Nuts, Bolts, Studs and Washer

Nuts and bolts for incorporation in the plant are preferably to conform to ISO metric coarse to ISO68, 261, 262, 272, 724, 885, 888 and 4759 or BS3643, 3692 and 4190. Other sizes or threads are permitted for threaded parts not to be disturbed in normal use or maintenance.

On equipment all bolts, nuts and washers shall be non-rusting material where they are in contact with non-ferrous parts in conductor clamps and fittings and elsewhere where specifically required by the Engineer.

All washers shall be included under this Contract, including devices and anti-vibration arrangements, which are to be subject to the approval of the Engineer. Taper washers are to be fitted where necessary.

Where there is risk of corrosion, bolts and studs shall be finished flush with the surface of the nuts and electro-chemical corrosion shall be avoided by bimetallic plates.

1.2.2 Welding

Where fabrication weld is liable to be highly stressed, the Contractor is to satisfy the Engineer before such welding commences, that the welders or welding operators are qualified in accordance with the requirements of the appropriate section of BS4872, part 1 or equivalent IEC/ISO standard specification.

The Engineer will inform the Contractor of the stages at which inspection will be required. It will be the Contractor's responsibility to notify the Engineer when one or more of the inspection stages will be reached and no further work is to be carried out until the specified stage has passed the Engineer's inspection

In addition to the above, the Engineer reserves the right to visit the Contractor's works at any reasonable time during fabrication of the items of plant and to familiarize himself with the progress made and the quality of the work to date.

All tests are to be carried out in accordance with the relevant ISO or other approved standards. Where required by the Engineer, non-destructive examination of the finished weld shall be made. If the examinations be by radiograph means, then the recommendations of BS EN 1435 or equivalent IEC/ISO where applicable are to be followed and the resulting negatives are to be made available to the Engineer.



1.2.3 Chromium Plating

The chromium plating of those components of the plant where specified and where offered by the Contractor is to comply with the requirements of ISO1456 and 1458 or BS1224.

Galvanizing shall be applied by the hot dipped process generally in accordance with ASTM A 123 for structural steel and ASTM A 153 for iron and steel hardware.

For structural steel galvanizing shall average not less than 0.61kg/m² (no individual specimen shall show less than 0.55kg/m² except for 7.35mm and heavier materials in which case galvanized shall average not less than 0.702kg/m² (no individual specimen shall show less than 0.61kg/m².

For iron and steel hardware, galvanizing shall be in accordance with Table 1 of ASTM A 153.

The zinc coating shall be smooth, clean, of uniform thickness and free from defects. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material.

1.2.4 Hot dip Galvanizing

Galvanizing shall be applied by the hot dipped process generally in accordance with ASTM A 123 for structural steel and ASTM A 153 for iron and steel hardware.

For structural steel galvanizing shall average not less than 0.61kg/m² (no individual specimen shall show less than 0.55kg/m² except for 7.35mm and heavier materials in which case galvanized shall average not less than 0.702kg/m² (no individual specimen shall show less than 0.61kg/m².

For iron and steel hardware, galvanizing shall be in accordance with Table 1 of ASTM A 153.

The zinc coating shall be smooth, clean, of uniform thickness and free from defects. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material.

For structural steel galvanizing shall average not less than 0.61kg/m² (no individual specimen shall show less than 0.55kg/m² except for 7.35mm and heavier materials in which case galvanized shall average not less than 0.702kg/m² (no individual specimen shall show less than 0.61kg/m².

For iron and steel hardware, galvanizing shall be in accordance with Table 1 of ASTM A 153.

The zinc coating shall be smooth, clean, of uniform thickness and free from defects. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material.

For structural steel galvanizing shall average not less than 0.61kg/m² (no individual specimen shall show less than 0.55kg/m² except for 7.35mm and heavier materials in which case galvanized shall average not less than 0.702kg/m² (no individual specimen shall show less than 0.61kg/m².

For iron and steel hardware, galvanizing shall be in accordance with Table 1 of ASTM A 153.

The zinc coating shall be smooth, clean, of uniform thickness and free from defects. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material.

1.2.5 Painting

All paint must meet appropriate standards, requiring at least two finishing coats on properly



prepared surfaces. Indoor control cubicles and cabinets, particularly where condensation might occur, must receive the same number of coats.

1.2.6 Rubbers

Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc.

1.2.7 Rivet

Rivets shall conform to the appropriate ISO and general use pan heads are preferred. Rivets on bearing surfaces are to be flat counter-sunk, driven flush. Whenever practicable, riveting is to be done by hydraulic tools and the rivets must completely fill the holes when closed. If loose, or if the heads are badly formed, cracked or eccentric to the shank or do not bear truly on the plate or bar, such rivets are to be cut out and replaced. All surfaces to be riveted must be in close contact throughout.

1.2.8 Forging

All the important forgings are to be examined by the latest methods for the detection of defects.

1.2.9 Casting

All castings are to be free from blowholes, flaws and cracks as is practicable. No welding, filling or plugging of defective parts is to be done without the sanction of the Engineer and then only with his approval in writing.

All cast-iron is to be of close-grained quality and is to be corrosion-resistant for those parts in contact with seawater. Cast-iron is not to be used for any part of the equipment which is in tension or which is subject to impact stresses. This clause is not intended to prohibit the use of suitable grades of cast-iron for parts where service experience has shown it to be satisfactory

1.3 ELECTRICAL DESIGN CRITERIA

1.3.1 System Condition and withstand level

The basic parameters on the network are set out as follows;

Particular	Parameter value
Nominal System Voltage	11 kV
Maximum System Voltage	12 kV
Rated frequency	50 Hz
Rated Insulation levels (RIV)	As per specification of each equipment
Full wave impulse withstand voltage (1.2/50 microsec.)	75 kVp
Rated one minute power frequency withstand voltage (rms)	28 kV
Rated short time current duration 3 second	25 kA
LT Voltage	230/400V

Note:

- The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000m, necessary altitude correction factor shall be applicable.
- The insulation and RIV levels of the equipment shall be as per values given in the respective



chapter of the equipment.

1.3.2 Creepage distance

The site is classified as light pollution level (C4 of ISO12944) with a creepage distance of 34.7 mm/kV.

1.3.3 Anti-condensation heater

Any item of electrical equipment which are liable to suffer from internal condition due to atmospheric or load variation shall be fitted with heating devices suitable for electrical operation at 230V AC 50Hz single phase of sufficient capacity to raise the internal ambient temperature by 5 degrees Celsius. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation.

Where fitted, a suitable terminal box and control switch shall be provided and mounted in an accessible position. Thermostat shall not be fitted.

1.4 TECHNICAL STANDARDS

The standards which shall be used in this Contract are listed below. Any standards proposed in place of or in addition to those specified shall be submitted for the Engineer's approval.

1.4.1 General Technical Specification

Name	No.	Title
I.E.C.	60060 (Part 1 to P4)	High Voltage Test Techniques
	60068	Environmental Test
	60117	Graphical Symbols
	60156	Method for the Determination of the Electrical Strength of Insulation Oils.
	60270	Partial Discharge Measurements
	60376	Specification and Acceptance of New Sulphur Hexafluoride
	60437	Radio Interference Test on High Voltage Insulators.
	60507	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems
	62271-1	Common Specification for High Voltage Switchgear & Control gear Standards
	60815	Guide for the Selection of Insulators in respect of Polluted Conditions
	60865 (P1 & P2)	Short Circuit Current - Calculation of effects.
	C.1/NFPA.70	National Electrical Code
	C37.90A	Guide for Surge Withstand Capability (SWC) Tests
	C63.21	Specification for Electromagnetic Noise and
ANSI	C63.3	Field Strength Instrumentation 10 KHz to 1 GHZ
	C36.4ANSI-C68.1	Techniques for Dielectric Tests
	C76.1/EEE21	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
	SI-4	Specification for Sound Level Metres
	Y32-2/C337.2	Drawing Symbols
	Z55.11	Gray Finishes for Industrial Apparatus and Equipment
NEMA		No. 61 Light Gray
	107T	Methods of Measurements of RIV of High Voltage



	ICS-II	Apparatus
		General Standards for Industrial Control and Systems
CSA	Z299.1-1978h	Part ICSI-109
	Z299.2-1979h	Quality Assurance Program Requirements
	Z299.3-1979h	Quality Control Program Requirements
	Z299.4-1979h	Quality Verification Program Requirements
		Inspection Program Requirements

1.4.2 Circuit Breakers

Name	No.	Title
I.E.C.	62271-100	High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
	62271-101	High-voltage switchgear and control gear - Part 101: Synthetic testing
	62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000V
	62271-110	High-voltage switchgear and control gear - Part 110: Inductive load switching
	62271-109	High-voltage switchgear and control gear - Part 110: Inductive load switching

1.4.3 Current Transformers, Voltage Transformers

Name	No.	Title
I.E.C.	60044-1	Current Transformers
	60044-2	Inductive Voltage Transformers
	60044-4	Instrument Transformers: Measurement of Partial Discharges
ANSI	C5713	Requirements for Instrument transformers
I.E.C.	60137	Insulated Bushings for Alternating Voltages above 1000V

1.4.4 Surge Arresters

Name	No.	Title
I.E.C.	60099-4	Metal oxide surge arresters without gaps
	60099-5	Selection and application recommendation
ANSI	C62.1	IEE Standards for S A for AC Power Circuits
NEMA	LA 1	Surge Arresters

1.4.5 Cubicles and Panels & Other Related Equipment

Name	No.	Title
I.E.C.	60068.2.2	Basic environmental testing procedures Part 2: Test B: Dry heat
	60529	Degree of Protection provided by enclosures
	60947-4-1	Low voltage switchgear and control gear
	61095	Electromechanical Contactors for household and



ANSI	60439 (P1 & 2)	similar purposes
	C37.20	Low Voltage Switchgear and control gear assemblies
	C37.50	Switchgear Assemblies, including metal enclosed bus. Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
NEMA	C39	Electric Measuring instrument
	C83	Components for Electric Equipment
	AB	Moulded Case Circuit and Systems
	CS	Industrial Controls and Systems
	PB-1	Panel Boards
	SG-5	Low voltage Power Circuit breakers
	SG-3	Power Switchgear Assemblies
	SG-6	Power switching Equipment
	5E-3	Motor Control Centers
	1248 (P1 to P9)	Direct acting indicating analogue electrical measuring instruments & their accessories

1.4.6 Disconnecting Switches / Load Break Switch

Name	No.	Title
I.E.C.	62271-102	High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches
ANSI	60265 (Part 1 & 2)	High Voltage switches
	C37.32	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
NEMA	C37.34	Test Code for high voltage air switches
	SG6	Power switching equipment

1.4.7 Protection and control equipment

Name	No.	Title
I.E.C.	60051: (P1 to P9)	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.
	60255 (Part 1 to 23)	Electrical relays
	60297(P1 to P4)	Dimensions of mechanical structures of the 482.6mm (19 inches) series
	60359	Expression of the performance of electrical & electronic measuring equipment
	60387	Symbols for Alternating-Current Electricity meters.
	60447	Man machine interface (MMI) - Actuating principles
	60521	Class 0.5, 1 and 2 alternating current watt hour metres
	60547	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI	81	Screw threads
	B18	Bolts and Nuts
	C37.1	Relays, Station Controls etc.
	C37.2	Manual and automatic station control, supervisory and associated telemetering equipment
	C37.2	Relays and relay systems associated with electric power apparatus
	C39.1	Requirements for electrical analog indicating instruments



1.4.8 Motors

Name	No.	Title
I.E.C.	60034 (P1 to P19)	Rotating electrical machines
	Document 2	Three phase induction motors
NEMA	MGI	Motors and Generators

1.4.9 Electronic Equipment and Components

Name.	No.	Title
I.E.C.	60068 (P1 to P5)	Environmental testing
	60326 (P1 to P2)	Printed boards
MIL	21B	
	833	
	2750	

1.4.10 Material and workmanship standards

Name	No.	Title
ASTM		Specification and tests for materials

1.4.11 Clamps and Connector

Name	No.	Title
NEMA	CC1	Electric Power connectors for sub station
	CC 3	Connectors for Use between aluminium or aluminium-Copper Overhead Conductors Hardware and insulators
IEC	60120	Dimensions of Ball and Socket Couplings of string insulator units
	60137	Insulated bushings for alternating voltages above 1000 V.
	60168	Tests on indoor and outdoor post insulators of ceramic material or glass for
		Systems with Nominal Voltages Greater than 1000 V.
	62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V
	60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
	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
	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.
	60372 (1984)	Locking devices for ball and socket couplings of string insulator units:
		dimensions and tests.
	60383 (P1 and P2)	Insulators for overhead lines with a nominal voltage above 1000 V.



	60433	Characteristics of string insulator units of the long rod type
	60471	Dimensions of Clevis and tongue couplings of string insulator units
ANSI	C29	Wet process porcelain insulators
	C29.1	Test methods for electrical power insulators
	C92.2	For insulators, wet-process porcelain and toughened glass suspension type
	C29.8	For wet-process porcelain insulators apparatus, post-type
	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
	B 230-82	Aluminium 1350 H19 Wire for electrical purposes
	B 231-81	Concentric - lay - stranded, aluminium 1350 conductors
	B 221	Aluminium - Alloy extruded bar, rod, wire, shape
	B 317-83	Aluminium-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)

1.4.12 Batteries and Battery Charger

Name	No.	Title
IEC	60896-21&22	Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
	60623	Vented type nickel Cadmium Batteries
	60622	Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
	60623	Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
	60896-11	Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
IEEE	485	Recommended practices for sizing of Lead Acid Batteries
	1115	Sizing of Ni-Cd Batteries
	1187	Recommended practices for design & installation of VRLA Batteries
	1188	Recommended practices for design & installation of VRLA Batteries
	1189	Guide for selection of VRLA Batteries

1.4.13 Wires and Cables

Name	No.	Title
ASTM	D-2863	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IEC	60096 (part 0 to p4)	Radio Frequency cables
	60183	Guide to the Selection of High Voltage Cables
	60189 (P1 to P7)	Low frequency cables and wires with PVC insulation and PVC sheath.
	60227 (P1 to P7)	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.



60228	Conductors of insulated cables
60230	Impulse tests on cables and their accessories
60287 (P1 to P3)	Calculation of the continuous current rating of cables (100% load factor).
60304	Standard colours for insulation for low-frequency cables and wires
60331	Fire resisting characteristics of Electric cables
60332 (P1 to P3)	Tests on electric cables under fire conditions.
60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV
754 (P1 and P2)	Tests on gases evolved during combustion of electric cables.

1.4.14 Paintings

Name	No.	Title
ANSI SSPEC	Z551	Gray finishes for industrial apparatus and equipment Steel structure painting council

1.4.15 Piping Valves & Specialities

Name	No.	Title
BS	5150	Specification for cast iron gate valves

1.4.16 Steel structures

Name	No.	Title
ANSI	B18.2.1	Inch series square and Hexagonal bolts and screws
	B18.2.2	Square and hexagonal nuts
	G8.14	Round head bolts
ASTM	A6	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
	A36	Specifications of structural steel
	A47	Specification for malleable iron castings
	A143	Practice for safeguarding against embrittlement of Hot Galvanized structural steel products and procedure for detaching embrittlement
	A242	Specification for high strength low alloy structural steel
	A283	Specification for low and intermediate tensile strength carbon steel plates of structural quality
	A394	Specification for Galvanized steel transmission tower bolts and nuts
	441	Specification for High strength low alloy structural manganese vanadium steel
	A572	Specification for High strength low alloy columbium-Vanadium steel of structural quality
AWS	D1-0	Code for welding in building construction welding inspection
	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
	A53	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
	A106	Seamless carbon steel pipe for high temperature service
	A284	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction.
	A234	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
	S181	Specification for forgings, carbon steel for general purpose piping
	A105	Forgings, carbon steel for piping components
	A307	Carbon steel externally threaded standard fasteners
	A193	Alloy steel and stainless-steel bolting materials for high temperature service
	A345	Flat rolled electrical steel for magnetic applications
	A197	Cupola malleable iron
ANSI	B2.1	Pipe threads (Except dry seal)
	B16.1	Cast iron pipe flanges and flanged fitting. Class 25, 125, 250 and 800
	B16.5	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
	B16.9	Factory-made wrought steel butt welding fittings
	B16.11	Forged steel fittings, socket-welding and threaded
	B16.14	Ferrous pipe plug, bushings and locknuts with pipe threads
	B16.25	Butt welding ends
	B18.1.1	Fire hose couplings screw thread
	B18.2.1	Inch series square and hexagonal bolts and screws
	B18.2.2	Square and hexagonal nuts
	B18.21.1	Lock washers
	B18.21.2	Plain washers
	B31.1	Power piping
	B36.10	Welded and seamless wrought steel pipe
	B36.9	Stainless steel pipe

1.5 PROTECTION OF ENVIRONMENT

1.5.1 Transportation

Impacts due to transportation of heavy equipment and construction material shall be minimized by limiting such transportations from 0700hrs to 1800hrs.

1.5.2 The Adherence to the Environmental Acts, Regulations and / or Guidelines

It is necessary that the Contractor shall work in accordance with the environmental and pollution control laws and regulations prevailing in Nepal. The Contractor shall comply with the recommendations made in the Environmental Management Plan and Environmental Monitoring Plan which is part of the Contract Document.



The Contractor shall be fully aware of environmental and pollution control regulations of Nepal and shall adhere those requirements fully. Key legislative instruments for environmental management in Nepal and JICA guideline include below but not limited to;

- Environmental Protection Act, 2076 B.S
- National Environmental Policy, 2076 B.S
- Environmental Protection Rule, 2077 B.S
- JICA Guidelines for Environmental and Social Considerations, 2022 A.D.
- Land Use Act, 2076 B.S
- Land Acquisition Act, 2034 (1977)
- Labour Act, 2074 (2017)
- Child Labour (Prohibition and Regulation) Act. 2056
- Soil and Watershed Conservation Act, 2039 (1982)
- Water Resources Act, 2049 (1992)
- Solid Waster Management Act, 2068 (2011)
- Electricity Act, 2049 (1992)
- Local Government Operation Act, 2074

In addition to the legislations listed above, there are other legislations that indirectly aim at environmental protection and pollution control which have to be adhered by the Contractor.

In order to provide safe and healthy environment for workers and the public, during construction and installation works, the Contractor shall achieve mitigating environmental impacts and risk minimization by appropriate safeguards through planning and implementation of the works.

The outlines of the environmental requirements of the Project are mentioned in the following documents;

- (a) Environmental Management Plan (EMP) and;
- (b) Environmental Monitoring Plan (EMoP)

The Contractor shall comply with all the requests.

The Contractor is required to submit Environmental Management Plan (Construction/Installation) for the construction and installation works upon award of the Contract. The following key areas have to be considered in preparation of EMP (Construction/Installation);

- (c) Potential environmental impacts and risks generally applicable to all sites and specific to particular sites
- (d) Propose measures to minimize or avoid and mitigate those impacts
- (e) Implementation arrangement of mitigation measures that will ensure the compliance



- (f) Monitoring of implementation of mitigation measures; Methods or tests used for assessment of environmental impacts and effectiveness of proposed measures including locations of monitoring and frequency of monitoring and reporting arrangement
- (g) The Contractor's staff shall have adequate knowledge of EMP (Construction/Installation) through educating and training.

The Contractor shall appoint a qualified Environment officer at construction sites to oversee the implementation of the EMP (Construction/Installation). The Environment officer shall be approved by the Employer.

The Bidders shall also take into consideration the relevant costs that will be incurred for the strict adherence of above safeguard measures and all the requirements stipulated in the environmental approvals, if any and the relevant documents forming part of such approvals obtained under the Nepal law with respect to the Project.

1.5.3 Environmental Conditions

1	Altitude of site above sea level not exceeding:	1000m
2	Maximum ambient air temperature:	45°C
3	Minimum ambient air temperature:	0°C
4	Average ambient air temperature over 24 hours;	18°C
5	Relative humidity (24 hours):	95%
6	Average annual rainfall:	3474 mm
7	Maximum recorded rainfall for 24 hours:	540 mm
8	Winds	
	Maximum wind speed	47 m/s
9	Storms	
	Frequency of thunderstorms:	High
	Average isokeraunic level:	60 days per annum
10	Atmospheric corrosivity category	C4 (ISO 12944) for Birauta substation
11	Seismic condition:	For electrical equipment: 0.5g (horizontal peak acceleration value)
		For Civil Structure: 0.3g(horizontal peak acceleration value)

1.6 CONTRACTOR'S RESPONSIBILITY

1.6.1 Safety of Personnel

The Contractor shall afford maximum safety to personnel directly engaged on this Contractor persons who, in the normal course of their occupation, find it necessary to utilize temporary works erected and to frequent the work area. Once any section of the plant has been made alive the Contractor, the Employer shall establish and agree to a system for ensuring the safety of personnel and equipment. While the plant is under the control of the Contractor, the Contractor shall be primarily responsible for the safety precautions. While the plant is under the control of the Employer, the Employer shall be primarily responsible for these precautions.

1.6.2 Contractor's Employees

The Contractor shall provide adequate transportation, accommodation, feeding and medical



facilities for all personnel in the employment. The Contractor is also to comply with the requirements of all relevant Labor Law of Nepal.

The Contractor shall be responsible for the behaviours on site of all personnel employed by himself.

1.6.3 Contractor's Key personnel

The Contractor shall have experienced and qualified administrative, accounting and store keeping staffs capable to undertake respective jobs. An office manager with adequate qualifications and experience to run such establishment efficiently must head the site office. The Contractor shall employ only experienced, competent and skilled office staff as required in the Tender document.

The line construction and supervisory staff of the Contractor shall be examined by the Employer to ensure their capability to perform proper quality of work as per Bidding Forms before Commencement of the work.

1.6.4 Progress Report

At monthly intervals the Contractor shall submit to the Employer written detailed progress reports (in triplicate) in an approved form indicating the stage reached in the design, ordering of material, manufacturing, delivery and supervision of erection of all components of plant with S-curve and photos. All variances from the agreed schedule are to be promptly reported. These reports shall be forwarded to promptly so that on receipt by the Employer the information contained therein is not more than seven days out of date. Copies shall also be forwarded to the Employer's representative on site.

The Contractor shall submit to the Employer a weekly return detailing for each portion of the works separately the numbers of the various classes of workmen employed by him on the site, the Contractor's and sub-Contractor's work shall be granted to the Employer at all reasonable times for the purpose of ascertaining progress.

1.6.5 Progress Meeting

The Contractor shall attend regular formal site progress meetings with the Employer, where progress and construction related issues will be reviewed. If required by the Employer, the Contractor shall prepare for issue the day before the meeting detailed schedules showing separately the erection, fixing, concreting, commissioning or other work activities planned for the next two week as well as progress achieved over the preceding week.

The Contractor shall also be required to attend other meetings from time to time on special subjects.

1.6.6 Material Storage

The Contractor may utilize the Employer's premises at the Birauta Substation construction site as a stockyard. However, if the available space is insufficient, the Contractor shall, at his own cost, procure/rent a stockyard of adequate size at a suitable location for storing equipment and materials intended for incorporation into the Works, as well as the Contractor's machinery and related items.

The storage yard shall serve as a common facility for storing materials related to substation works, transmission line works, and distribution line works. The Contractor shall bear full responsibility for the management of the storage yard, including the provision of adequate security to safeguard the stored equipment and materials against theft or damage. The Employer shall not be held liable in any way for any loss or damage to the stored items, whether due to theft or other causes.



The Contractor shall ensure that all equipment and materials are stored in an orderly manner. The storage yard will remain available to the Contractor until the completion and handover of the Works at the Birauta Substation. Upon completion, the Contractor shall clear the yard of all remaining items and debris and return it to the Employer in a clean and acceptable condition.

All costs associated with the establishment and management of the storage facility shall be deemed included in the Contract Price.

Extended storage of materials along the transmission and distribution line routes shall not be permitted. All small items of material shall be distributed to work crews on a daily basis and shall not be stored overnight at the worksite.

Cables, conduits, conductor reels, and similar items may be temporarily placed at the worksite shortly before installation, provided that protective packaging such as crating and reel lagging remains intact. Poles may also be temporarily placed at structure locations shortly before installation.

All materials placed at the worksite, including poles, cables, and conductors, shall be positioned to avoid damage and to ensure they do not obstruct pedestrian or vehicular traffic.

Any damage resulting from improper placement of equipment or materials by the Contractor shall be rectified by the Contractor, at his own cost, in a manner acceptable to the Project.

1.6.7 Site Sign Boards

The Contractor shall temporarily install movable site signboards at each construction site. The content, including text and any images or symbols displayed on the signboards, shall be subject to the Engineer's prior approval.

CHAPTER 2:

POWER CABLES FOR UNDERGROUND



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CHAPTER 2: POWER CABLES FOR UNDERGROUND

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
2.1	General	1
2.2	MV (11kV) CABLES	1
2.2.1	General Requirements.....	1
2.2.2	Description.....	2
2.2.3	Accessories for MV Cables.....	4
2.2.4	Packing	5
2.2.5	Inspection and Tests	6
2.2.6	Performance Guarantee	7
2.3	Cable Termination Kit and Joint kit for XLPE	7
2.3.1	General Requirements.....	7
2.3.2	Description.....	8
2.3.3	Other Requirements.....	8
2.3.4	Testing	9
2.4	LT CABLES	10
2.4.1	General Requirements.....	10
2.4.2	Packing and forwarding	13
2.4.3	Tests on cables	14
2.4.4	Tests on accessories.....	14
2.5	SERVICE CABLES	14
2.5.1	General Requirements.....	14
2.5.2	Packing and forwarding	17
2.5.3	Tests on cables	18
2.5.4	Tests on accessories.....	18
2.6	Prior Investigation	18
2.6.1	Desktop Investigation.....	18
2.6.2	On-site investigation	18
2.7	INSTALLATION	19
2.7.1	Laying and Installation of HT and LT Cable	19
2.7.2	CABLE TERMINATION AND JOINT	27



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2.1 GENERAL

Cross-linked polyethylene insulated (XLPE) and high density PVC sheathed Aluminium cables shall be used for MV (11kV) and LV (230/400 V) underground distribution network.

The standards to be applied for design, manufacture and tests of cables and accessories shall be the following IEC Recommendations and/or equivalent internationally recognized standards.

IEC 60060	:	High Voltage Test Techniques
IEC 60227	:	Polyvinyl chloride insulated cables of rated voltage up to and including 450/750 V
IEC 60228	:	Conductors of insulated cables
IEC 60287	:	Electric cables - Calculation of the current rating
IEC 60304	:	Standard colors for insulation for low frequency cables and wires
IEC 60502	:	Power cables with extruded insulation and their accessories for rated voltage from 1 kV (Um=1.2kV) up to 30 kV (Um=36kV)
IEC 60811	:	Common test methods for insulating materials of electric cables
IEC 61089	:	Round wire concentric lay overhead electrical stranded conductors

2.2 MV (11KV) CABLES

2.2.1 General Requirements

The XLPE insulated cables shall conform to the requirements of IEC 60502-2 (applicable clauses only). The terminating accessories shall conform to IEC 60502 or equivalent standard. The offered cables and its terminating accessories shall be compatible with each other.

The 6/10 (12) kV XLPE cable shall be three core, armoured, stranded, compacted conductor Aluminium, core screening by a layer of semiconducting XLPE, XLPE insulation, insulation screening by a layer of semiconducting XLPE. The core screening, insulation and insulation screening to be triple extruded and dry cured. The outer sheath shall be black HDPE. Bidder shall offer necessary layers such as water blocking, separation tape, binder tapes etc. additionally as per their manufacturing practices for meeting required performance of the offered cable.

The cable shall be suitable for installing in the climate conditions.

Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

Cable sheath shall be embossed/permanently printed "ELECTRIC CABLE 10000V". The size of the lettering shall not less than 15% of the approximate cable diameter and shall not be larger than 13mm. The gap between the end of one set of embossed/permanently printed characters and the beginning of the next set shall be not greater than 250mm. In addition, the manufacturer and year of manufacture shall be embossed/permanently printed on the cable at regular intervals and shall not affect the spacing of the other characters.



Each core shall be identifiable throughout the cable either by colour or numbering.

Repaired cables shall not be accepted.

Allowable tolerance on the overall diameter of the cables shall be + 2 mm for OD up to 60 mm and + 3 mm for OD above 60 mm.

2.2.2 Description

(1) Conductor

The conductor shall be of as specified in the Price Schedule. The shape of conductor shall be compacted having high compactness and smooth surface finish. All conductors shall be stranded, circular and compacted and comply with IEC 60228.

(2) Conductor Screen

The conductor screen shall consist of extruded semi-conducting XLPE. Semiconducting separator tapes may be applied between conductor and the extruded semiconductor XLPE. The conductor screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids. The conductor shall be screened with an extruded layer of semi-conducting material of 0.6mm thickness for the cables.

(3) Insulation

The conductor screen shall consist of extruded semi-conducting tape or insulation. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor insulation. The conductor screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids. The insulation material shall be cross-linked by a dry process. A cross-linking process using steam curing will not be permitted. The thickness of insulation shall be determined by taking the average of number of measurements and shall be not less than the values tabulated in IEC 60502.

(4) Insulation Screen

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE in combination with 1 non-magnetic metallic shield.

The insulation screen shall comprise a non-metallic semi-conducting polyethylene part in combination with a metallic part. The non-metallic semi-conducting part shall be applied directly upon insulation of the core and shall comprise a layer of extruded semiconducting polyethylene compound. The conductor screen, insulation and semiconducting part of insulation screen layer shall be applied to the conductor in common extrusion process with dry curing system.

(5) Insulation and Semi Conducting Screens

The XLPE insulation and semi conducting screens shall be triple extruded and dry cured.



(6) Moisture Barrier

The longitudinal water barrier shall be applied over insulation screen by a layer of nonwoven synthetic tape with suitable water swellable absorbent.

(7) Metallic Screen

The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A binder tape of annealed plain copper shall be applied in the form of an open helix over the copper wire screen. Wire screen shall be designed to meet the requirement of the short circuit rating of 2.14kA per phase per second. The metallic part shall be stranded copper applied over the layer of semi conducting compound. There shall be single layer of copper wires adequately spaced apart on each core of Power cable.

(8) Outer Sheath

The outer sheath shall consist of extruded black colored HDPE. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack. The outer sheath shall have adequate strength and thickness to withstand the test voltage and mechanical tests and be suitable for ambient conditions at site. The outer sheath material shall be capable of withstanding the highest temperature achieved with the cable at its rated current without damage or deformation at site ambient conditions.

(9) Armouring

The armour of cables shall consist of aluminum wires or strips. The armoring shall be applied such that the minimum area of coverage shall be 90% and the gap between any two armour strips/ wire shall not be more than the width of strip/ diameter of armour wire. The galvanized steel strips/wire shall comply with the requirements of IEC with the latest amendments.

In case of Single core cable, armouring shall be of Non-magnetic material with dimensions as per relevant IEC with latest amendments. No tolerance on the negative side shall be acceptable.

(10) Filler

In case of three-phase core cable, the 3 cores shall be laid up to form a circular shape using PVC fillers. The gaps between the conductors have to be filled with extruded thermosetting material, which is compatible with other components of the cable and bound overall with PVC over sheath.

(11) Core Indication

The cores shall be identified preferably with colored insulation or colored tape, which are laid helically around each conductor between insulation semi-conductor and metallic screen.

(12) Marking on Cable

The outer protective sheath of the cables shall carry the following indications:

- Name of Manufacturer



- The year of manufacture
- The rated voltage
- An indication of the insulation
- Cross section of the phase conductor cores
- Phase identification

Phase identification for three core cables shall be in accordance with the following:

- Phase A (R): Red
- Phase B (Y): Yellow
- Phase C (B): Blue

(13) Rating and Quantity

Rating for the required quantity of the power cable shall be as shown below.

Characteristics	Unit	Requirements
Nominal system voltage	kV	11
Cable size	mm ²	As specified
AC test voltage for 5 min	kV	15
Insulation level	-	-
Power Frequency withstand voltage	rms kV	28
Impulse withstand voltage	kV	75
Applicable standard		IEC 60502

2.2.3 Accessories for MV Cables

The cable jointing accessories shall include all the straight through joints. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. Unless specified separately in the Price Schedule, cable end terminating kits shall be deemed included as part of cable jointing accessories.

The joints shall be suitable for tropical conditions. Straight joints shall be heat shrink type with compression ferrules. Each joint shall include all necessary material and components for effecting a reliable and durable joint. Particular importance is attached to the proper provision of stress-relieving materials and tubing.

The straight through joints and cable end terminations shall be of proven design and should have been type tested as per relevant IEC standard. A list shall be furnished indicating supply of such cable jointing accessories which are successfully operating in other projects.

The detailed description on jointing procedure shall be furnished during detailed engineering.

The cable end terminations shall be of anti-fog type and shall be of Polymeric type suitable for withstanding the climatic conditions with required Creepage distance as specified in bidding documents. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable of withstanding mechanical forces during normal and short circuit operations.

2.2.4 Packing

Materials supplied under the Contract shall be packed for transportation and storage in the following manners. General requirements for packing, delivery and storage shall be referred as follows.

(1) Cable Drum

Cables shall be supplied in non-returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.

Standard drum lengths for manufacturing shall be finalized during detailed engineering.

Each drum shall carry the manufacturer's name, the Employer's name, address and contract number and type, size and length of the cable, net and gross weight stencilled 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 wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

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 heat shrink caps so as to eliminate ingress of water during transportation and erection.

The following information be stencilled on the drum with either waterproof ink or oil paint:

- (a) Reference of IEC standard.
- (b) Manufacturer's name or trademark.
- (c) Type of cable and voltage grade.
- (d) No. of cores.
- (e) Nominal cross-sectional area of conductor
- (f) Cable code.
- (g) Length of cable on the drum
- (h) Gross weight
- (i) Direction of rotation of drum (by means of an arrow)
- (j) Position of outer end of cable
- (k) Year of manufacture
- (l) Reference of Tender No. I P.O. No. date
- (m) Property of "NEA"
- (n) Name of consignee and the destination.



Each consignment shall be accompanied by a detailed packing list, containing the following information;

- (o) Name of consignee
- (p) Details of consignment
- (q) Destination
- (r) Total weight of consignment
- (s) Handling and unpacking instruction
- (t) Bill of materials, indicating contents of each package.

2.2.5 Inspection and Tests

Through the work execution, various inspections and tests on the progressing works will be ordered to the Contractor by the Employer.

Inspections and tests will be carried out after completion of the works section by section. The Contractor shall perform all the inspections and tests in accordance with IEC Standard.

(1) Tests at works

The following tests shall be carried out at the manufacturer's plant before shipment as far as applicable for type of conductors and cables.

- (a) 11 kV XLPE Power cable
 - (i) Appearance check
 - (ii) Conductor resistance measurement
 - (iii) Capacitance measurement
 - (iv) Insulation resistance measurement
 - (v) A.C. withstand voltage
 - (vi) A.C. long duration withstand voltage
 - (vii) Impulse withstand voltage
 - (viii) A.C. long duration breakdown voltage
 - (ix) Impulse break-down voltage
 - (x) Dielectric loss tangent
 - (xi) Temperature-voltage characteristics
 - (xii) Dimension
 - Conductor outermost diameter
 - Insulation thickness
 - Sheath thickness
 - Over-sheath thickness
 - Thickness of each tape
 - Interval of tap lapping
 - Total diameter
 - (xiii) Bending withstand characteristic



- (xiv) Hot Set Test of XLPE insulation
- (xv) Water Penetration Test
- (xvi) Over-Sheath
 - Tensile strength
 - Thermal aging
 - Oil-proof
 - Non-inflammability
 - Thermal deformation
 - Hardness

(b) Sealing/termination ends or straight joints

- (i) Appearance and structure check
- (ii) A.C. long duration withstand voltage
- (iii) Impulse withstand voltage
- (iv) A.C. long duration breakdown voltage
- (v) Impulse breakdown voltage
- (vi) Porcelain or epoxy insulator, construction
 - Power frequency flash-over voltage (dry)
 - Power frequency flash-over voltage (wet) 50% impulse flash-over voltage
 - Cantilever strength
 - Thermal mechanical performance

(c) Tests on Completion

After completely installing the 11 kV XLPE power cables, sealing ends and other conductors at site, the following tests shall be carried out by the Contractor

- Insulation resistance test

2.2.6 Performance Guarantee

The performance figures quoted on schedule of Technical Data shall be guaranteed within the tolerance permitted by relevant standards and shall become part of the Contract. In case of failure of the cables to meet the guarantees, the Employer reserves the right to reject the item. The Contractor shall have to rectify/replace the defect/defective part at no extra cost to the Employer and without delaying the commissioning schedule.

2.3 CABLE TERMINATION KIT AND JOINT KIT FOR XLPE

2.3.1 General Requirements

This specification covers the design, manufacture, factory test, supply and delivery of heat shrinkable type termination and joint kits for 11 kV, 3 core screened, armoured, with aluminium conductor XLPE cables suitable for earthed system and conforming to relevant standard with latest amendment, if any.



The termination kits for the use on 50 Hz, 3 phase system with earthed neutral for working voltage of 11 KV.

The Termination kit and jointing kit shall be heat shrinkable if not specified otherwise in either section GTP or the Price schedule

2.3.2 Description

All high voltage termination and jointing kits shall be standard quality type. They shall be factory engineered kits containing all the necessary components to reinstate the cable insulation, metallic shielding of each core, together with the reinstatement of the sheath and of the cable being terminated.

The heat shrinkable termination and joint kit shall be manufactured and tested in accordance with the latest version of IEC, or any other national or international standard that ensures at least a substantially equal quality to the standard.

The manufacturer of the termination and joint kit (Indoor, outdoor and straight- through) must have been accredited with ISO 9001 quality certification. The heat shrinkable terminations offered shall be of proven design and make, which have already been extensively used and fully type tested.

The entire termination and joint kit shall be environmentally sealed and capable of preventing the ingress of external moisture and contamination.

Kits shall contain sufficient cleaning solvents and cleaning clothes for the proper making of the joint or termination.

Voltage stress relief shall be provided, and this may be inherent in the heat recoverable polymeric material.

The terminating or jointing materials shall not be subjected to storage limitations such as controlled temperature or humidity restrictions, nor have shelf life limitations.

2.3.3 Other Requirements

The outdoor termination kits shall be suitable for terminating the cable at steel cross arm complete with brackets, terminals, saddles and all necessary materials for fixing the termination. The heat shrinkable termination kit to be supplied and installed under this scope of work shall be capable enough to cope with all the weather changes.

Terminations that do not require manually built stress relief cones or field pouring compound are preferred.

The term heat shrinkable refers to extruded or moulded polymeric materials which are cross-linked to develop elastic memory and supplied in expanded or otherwise deformed size/shape, subsequently heating in a non-constrained state to a temperature above the shrink temperature resulting in the material recovering or shrinking to its original shape.



Since the sealant or adhesives (to be used for environment sealing) between the heat shrinkable materials and XLPE cables shall be exposed to high electrical stresses, they must be track resistant.

The heat shrinkable polymer materials being used for external leakage insulation between the high voltage of conductors and grounds should be weather resistant.

All cuts/nicks inadvertently occurred to XLPE insulation must be rendered discharge free by using suitable discharge suppression compound.

The heat shrinkable tubing may be either extruded or moulded type.

Higher thickness of heat shrinkable sleeves shall be preferable to counter erosion due to pollution.

Rubber components should be made from proven quality of tuber with tested curing properties.

The semi conducting portion of the stress cone should be vulcanized with insulation so that both semi conducting and insulation portion becomes an integrated part.

The stress cone must be of proven design of stress control.

The moulding of rubber components should be aimed to achieve a smooth finish on interior and exterior of the components.

In case of outdoor terminations, the suitable provision for covering the cable cores with re-useable protective system from the crotch seal to the bottom of stress cone should be made.

Accessories shall match the cable test ratings in all respects. The material and components not specifically stated in the specification, but which are essential for satisfactory operation of the equipment shall be included without any extra cost.

The termination and joint kits shall be of suitable for following cables:

- Outdoor and Indoor use for 11 kV, 3-cores Aluminum XLPE insulated Power cables.

2.3.4 Testing

The routine tests of the kits shall be done at manufacturer's plant in accordance with IEC or other equivalent national or international standards including following tests.

- Appearance Test
- Construction Test
- High Voltage Test

Manufacturer shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & type test reports shall be submitted for Employer's approval.



2.4 LT CABLES

2.4.1 General Requirements

The XLPE insulated cables shall conform to the requirements of IEC 60502-2 (applicable clauses only). The terminating accessories shall conform to IEC 60502 or equivalent standard. The offered cables and its terminating accessories shall be compatible with each other.

Single core, Three and half (3.5) Core and Four (4) core Cross linked Polyethylene (XLPE) insulated, FRLS PVC sheathed, armoured power cables shall be used for LT underground distribution network.

The cable shall be suitable for installing in the climate conditions.

Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

Cable sheath shall be embossed/permanently printed "ELECTRIC CABLE 1100V". The size of the lettering shall not less than 15% of the approximate cable diameter and shall not be larger than 13mm. The gap between the end of one set of embossed/permanently printed characters and the beginning of the next set shall be not greater than 250mm. In addition, the manufacturer and year of manufacture shall be embossed/permanently printed on the cable at regular intervals and shall not affect the spacing of the other characters.

Each core shall be identifiable throughout the cable either by colour or numbering.

Repaired cables shall not be accepted.

Allowable tolerance on the overall diameter of the cables shall be + 2 mm for OD upto 60 mm and + 3 mm for OD above 60 mm.

(1) Conductor

The conductor shall be as specified in the Price Schedule. The shape of conductor shall be compacted having high compactness and smooth surface finish. All conductors shall be stranded, circular and compacted and comply with IEC 60228. No joint shall be made after it is stranded.

(2) Insulation

The insulation shall be suitable for LT system voltage and the insulating material shall be cross linked Polyethylene (XLPE) and applied by extrusion process as per IEC and its latest amendments.

The insulating material shall have excellent electrical properties with regard to resistivity, dielectric constant and loss factor and shall have high tensile strength and resistance to abrasion. This shall not deteriorate at elevated temperatures or when immersed in water.

The insulation shall be fire resistant and resistant to chemicals like acids, alkalis, oils and ozone.



The insulation properties shall be stable under thermal conditions arising out of continuous operation at conductor temperature of 90°C rising momentarily to 250°C under short circuit conditions. It shall be free from any foreign material or porosity visible to the unaided eye.

The insulation shall be so applied that it fits closely on the conductor, and it shall be possible to remove it without damaging the conductor.

The average thickness of insulation shall not be less than the nominal value as specified in relevant IEC with latest amendments.

Tolerance on insulation thickness shall be as per relevant IEC. The insulation shall withstand mechanical and thermal stress under both steady state and transient operating conditions.

(3) Core identification (for multiple core cables)

Individual core of multi-core cables shall be colour coded and/or numbered for proper identification.

All cores insulation shall be black colored. For cores identifications, a XLPE colored line (1mm width X 0.5 mm height) shall be extruded over the insulation.

Red line shall represent - R ph.

Yellow line shall represent - Y ph.

Blue line shall represent - B ph.

For Neutral: as core already black, extruded line not required over the insulation. In 2 core cables, phase core shall be red colored extruded line. The manufacturer's name along with the order no. shall be printed (noncontact type) on the outer sheath.

(4) Fillers and Laying up of cores (for multiple core cables)

In multi core cables, the cores shall be laid together with a suitable right hand lay. The interstices shall be filled with non-hygrosopic material. Further, the compounds used with fillers shall be such as to have no deleterious effect on other components of the cable and to be stable at cable temperatures.

(5) Inner sheath (common covering)

The laid-up cores shall be provided with inner sheath applied by extrusion process. It shall be ensured that the shape is as circular as possible. It shall be applied to fit closely on to the laid-up cores and shall be possible to remove easily without causing any damage to the underlying insulated cores.

The thickness of the inner sheath shall be as per relevant IEC. No tolerance on the negative side shall be acceptable.



(6) Armouring

The armour of cables shall consist of either galvanized round steel wires or galvanized steel strips. The armoring shall be applied such that the minimum area of coverage shall be 90% and the gap between any two armour strips/ wire shall not be more than the width of strip/ diameter of armour wire. The galvanized steel strips/wire shall comply with the requirements of IEC with latest amendments.

In case of Single core cable armouring shall be of Non-magnetic material with dimensions of the galvanized steel strip/wire shall be as per relevant IEC with latest amendments. No tolerance on the negative side shall be acceptable.

The direction of lay of the armour shall be left hand. When one or more layers of proofed plastic tape are applied over the laid-up cores as a binder, the thickness of such tapes shall not be construed as part of the extruded inner sheath.

The dimensions of armour round wires shall be as per IS-7098(Part-I):1988.

The joints in armour wire shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire shall be at least 300mm from the nearest joint in any other armour wire in the completed cable. The single core cable shall not have any GI wire armour.

(7) Outer Sheath

The outer sheath shall consist of extruded tough outer sheath of PVC compound insulation over the armouring. The colour of the outer sheath shall be black.

The outer sheath shall be applied by extrusion process, it shall be tightly applied:

- (a) Over the insulation in case of unarmoured single core cables.
- (b) Over the armouring in case of armoured cables.

(8) Identification mark

The outer sheath of the cable shall bear following identification parameters embossed/permanently printed at intervals of length of one meter of cable, throughout the cable:

- (i) Name of manufacturer
- (ii) Year of manufacture
- (iii) Voltage grade
- (iv) Size of cable
- (v) Cable code
- (vi) Name of purchaser "NEA"
- (vii) Successive length
- (viii) Marking for FRLS cable



2.4.2 Packing and forwarding

Materials supplied under the Contract shall be packed for transportation and storage in the following manners. General requirements for packing, delivery and storage shall be referred as follows.

(1) Cable Drum

Cables shall be supplied in non-returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.

Standard drum lengths for manufacturing shall be finalized during detailed engineering.

Each drum shall carry the manufacturer's name, the Employer's name, address and contract number and type, size and length of the cable, net and gross weight stencilled 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 wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

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 heat shrink caps so as to eliminate ingress of water during transportation and erection.

The following information be stencilled on the drum with either waterproof ink or oil paint:

- (i) Reference of IEC standard.
- (ii) Manufacturer's name or trademark.
- (iii) Type of cable and voltage grade.
- (iv) No. of cores.
- (v) Nominal cross-sectional area of conductor
- (vi) Cable code.
- (vii) Length of cable on the drum
- (viii) Gross weight
- (ix) Direction of rotation of drum (by means of an arrow)
- (x) Position of outer end of cable
- (xi) Year of manufacture
- (xii) Reference of Tender No. I P.O. No. date
- (xiii) Property of "NEA"
- (xiv) Name of consignee and the destination.

Each consignment shall be accompanied by a detailed packing list, containing the following information;

- (i) Name of consignee
- (ii) Details of consignment
- (iii) Destination
- (iv) Total weight of consignment
- (v) Handling and unpacking instruction
- (vi) Bill of materials, indicating contents of each package.



2.4.3 Tests on cables

All XLPE insulated cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC. Type test reports shall be submitted for Employer's approval.

2.4.4 Tests on accessories

Contractor shall submit type test reports for accessories, as per IEC 60502 or equivalent standards for Employer's acceptance.

2.5 SERVICE CABLES

2.5.1 General Requirements

Service cables shall be 1100 volts grade, LT Cable, multiple core, Cross linked Polyethylene (XLPE) , FRLS PVC sheathed, armoured cables for effectively earthed systems.

Sizes of service cable for various consumers will be as per below mentioned table:

SI No.	Consumer type	Cable size
1	Service Cable along with all accessories required for connection of meter to service pillar (single phase 16 A)	2Cx6 mm ²
2	Service Cable along with all accessories required for connection of meter to service pillar (single phase 30 A)	2Cx10 mm ²
3	Service Cable along with all accessories required for connection of meter to service pillar (single phase 60 A)	2Cx35 mm ²
4	Service Cable along with all accessories required for connection of meter to service pillar (3 phase up to 25 kVA)	3Cx25+16mm ²
5	Service Cable along with all accessories required for connection of meter to service pillar (3 phase 25 to 50 kVA)	3Cx70+35mm ²

(1) Conductor

The conductor of the cable shall be made from high conductivity, Electrolytic H4 Grade, stranded aluminium to form compacted and circular /shaped conductor having resistance within limits as specified in relevant IEC or equivalent with latest amendments.

Before stranding, the conductor shall be circular in cross section, uniform in quality, solid, smooth and free from scale, sharp edges and other defects.

Conductor shall conform to the standards for permissible number of joints in any one of the single wires forming every complete length of conductor, for location of joints in same layer of conductors and for method of making such joints. No joint shall be made in any conductor after it is stranded.

(2) Insulation

The insulation shall be suitable for LT system voltage and the insulating material shall be cross linked Polyethylene (XLPE) and applied by extrusion process as per IEC and its latest amendments.

The insulating material shall have excellent electrical properties with regard to resistivity, dielectric

constant and loss factor and shall have high tensile strength and resistance to abrasion. This shall not deteriorate at elevated temperatures or when immersed in water.

The insulation properties shall be stable under thermal conditions arising out of continuous operation at conductor temperature of 90°C rising momentarily to 250°C under short circuit conditions. It shall be free from any foreign material or porosity visible to the unaided eye. The insulation shall be so applied that it fits closely on the conductor, and it shall be possible to remove it without damaging the conductor.

The average thickness of insulation shall not be less than the nominal value as specified in relevant IEC with latest amendments.

Tolerance on insulation thickness shall be as per relevant IEC. The insulation shall withstand mechanical and thermal stress under both steady state and transient operating conditions.

(3) Core identification (for multiple core cables)

Individual core of multi-core cables shall be color coded and/or numbered for proper identification.

All cores insulation shall be black colored. For cores identifications, a XLPE colored line (1mm width X 0.5 mm height) shall be extruded over the insulation.

- Red line shall represent - R ph.
- Yellow line shall represent - Y ph.
- Blue line shall represent - B ph.

For Neutral: as core already black, extruded line not required over the insulation. In 2 core cables, phase core shall be red colored extruded line. The manufacture's name along with the order no. shall be printed (noncontact type) on the outer sheath.

(4) Fillers and Laying up of cores (for multiple core cables)

In multi core cables, the cores shall be laid together with a suitable right hand lay. The interstices shall be filled with non-hygroscopic material. Further, the compounds used with fillers shall be such as to have no deleterious effect on other components of the cable and to be stable at cable temperatures.

(5) Inner sheath (common covering)

The inner sheath shall be extruded PVC, Type ST2, compatible with thermal rating of insulation conforming to IEC. The laid up cores shall be provided with inner sheath applied by extrusion process. It shall be ensured that the shape is as circular as possible. It shall be applied to fit closely on to the laid up cores and shall be possible to remove easily without causing any damage to the underlying insulated cores.

The thickness of the inner sheath shall be as per relevant IEC. No tolerance on the negative side



shall be acceptable.

(6) Armouring

The armour of cables shall consist of either galvanized round steel wires or galvanized steel strips as below mentioned table.

Sl. No.	Size of cable	Armour type
1	2Cx6 mm ²	Galvanized steel Round Wire
2	2Cx10 mm ²	Galvanized steel Round Wire
3	2Cx35 mm ²	Flat Strip
4	3Cx25+16 mm ²	Flat Strip
5	3Cx70+35 mm ²	Flat Strip

The armoring shall be applied such that the minimum area of coverage shall be 90% and the gap between any two armour strips/ wire shall not be more than the width of strip / diameter of armour wire. The galvanized steel strips/wire shall comply with the requirements of IEC with latest amendments.

The direction of lay of the armour shall be left hand. When one or more layers of proofed plastic tape are applied over the laid-up cores as a binder, the thickness of such tapes shall not be construed as part of the extruded inner sheath.

The dimensions of armour round wires shall be as per IEC 60502-1.

The joints in armour wire shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire shall be at least 300mm from the nearest joint in any other armour wire in the completed cable. The single core cable shall not have any GI wire armour.

(7) Outer sheath

The outer sheath shall consist of extruded tough outer sheath of PVC, Type ST2 compound insulation over the armouring. The colour of the outer sheath shall be black.

The outer sheath shall be applied by extrusion process, it shall be tightly applied over the armouring.

(8) Identification mark

The outer sheath of the cable shall bear following identification parameters embossed/permanently printed at intervals of length of one meter of cable, throughout the cable:

- (i) Name of manufacturer
- (ii) Year of manufacture
- (iii) Voltage grade
- (iv) Size of cable
- (v) Cable code



- (vi) Name of purchaser "NEA"
- (vii) Successive length
- (viii) Marking for FRLS cable

2.5.2 Packing and forwarding

Materials supplied under the Contract shall be packed for transportation and storage in the following manners. General requirements for packing, delivery and storage shall be referred as follows.

(1) Cable Drum

Cables shall be supplied in non-returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.

Standard drum lengths for manufacturing shall be finalized during detailed engineering.

Each drum shall carry the manufacturer's name, the Employer's name, address and contract number and type, size and length of the cable, net and gross weight stencilled 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 wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

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 heat shrink caps so as to eliminate ingress of water during transportation and erection.

The following information be stencilled on the drum with either water proof ink or oil paint:

- (i) Reference of IEC standard.
- (ii) Manufacturer's name or trademark.
- (iii) Type of cable and voltage grade.
- (iv) No. of cores.
- (v) Nominal cross-sectional area of conductor
- (vi) Cable code.
- (vii) Length of cable on the drum
- (viii) Gross weight
- (ix) Direction of rotation of drum (by means of an arrow)
- (x) Position of outer end of cable
- (xi) Year of manufacture
- (xii) Reference of Tender No. I P.O. No. date
- (xiii) Property of "NEA"
- (xiv) Name of consignee and the destination.

Each consignment shall be accompanied by a detailed packing list, containing the following information;

- (i) Name of consignee
- (ii) Details of consignment
- (iii) Destination
- (iv) Total weight of consignment



- (v) Handling and unpacking instruction
- (vi) Bill of materials, indicating contents of each package.

2.5.3 Tests on cables

All XLPE insulated cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC. Type test reports shall be submitted for Employer's approval.

2.5.4 Tests on accessories

Contractor shall submit type test reports for accessories, as per IEC 60502 or equivalent standards for Employer's acceptance.

2.6 PRIOR INVESTIGATION

2.6.1 Desktop Investigation

The mapped details of the underground utilities such as water, sewage, telecom etc. may also be provided to the Contractor for reference (wherever possible), but the Contractor shall identify other utility owners within the project area by himself.

The Contractor shall request the asset information from identified utility owners.

The Contractor shall collate all data on utility owners and their assets, and submit the report to the Employer.

2.6.2 On-site investigation

The Contractor shall carry out the mapping of the existing underground utilities by GPS and GPR (Ground Penetrating Radar) equipment to avoid damage to any utilities at the time of execution.

The Contractor shall submit the specification sheet of GPR equipment for prior approval of the Employer. Vehicle type GPR equipment shall not be accepted, a handcart high density array (100 mm or closer antenna separation) shall be used for the survey area.

GPR equipment shall be capable of recording the data or shall be capable of real-time mark up.

The Contractor is encouraged to get the absolute geospatial location of utilities referenced to three dimensions using a national coordinate grid system and datum.

Positioning of the array shall be continuously monitored and recorded using eight GNSS (Global Navigation Satellite System) or total station and at an absolute accuracy of less than 100 mm.

The total station or GNSS system shall be used in accordance with the manufacturer's instructions, procedures, calibration and any instrument or process limitations.

GPR survey, post-processing and the analysis shall be conducted by well-experienced and skilled operators.



All survey points shall be either:

- (a) Stored digitally within the total station of GNSS system as coded detail points for post-processing, or
- (b) Plotted directly onto digital drawing on-site using a precision mobile system for data collection.

Frequency bands used for radar should be suitable for searching underground object in a range of 3m from the ground. It is preferable if the radar can detect a range of 5 meters from the ground.

Minimum data collection speed shall be above 1m/sec.

Where the survey detects anomalies other than those caused by utilities, these shall be recorded.

2.7 INSTALLATION

2.7.1 Laying and Installation of HT and LT Cable

(1) Laying and Installation

The Bidder is advised to visit the site and acquaint themselves with the topography, infrastructure etc. The Contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning of XLPE cables in all respects. In general, the cable laying operation shall be in accordance with the best internationally accepted practices and procedures and in accordance to manufacturers' recommendation.

Cable drum shall be positioned in such a way that the axle of the drum is perpendicular to the cable trench. The cable shall come off the drum always at the lower part in order to minimize stress. If the laying is done by the winch it has to be equipped with a tension release in order to avoid any excess stresses on the cable. The cable tension as well as the continuity of the laying operation shall be monitored by instruments and shall not exceed limits given by the manufacture's recommendation. Winching equipment which doesn't fulfil the above requirements will be rejected.

Cable rollers shall be used to roll off the cables from the drums. The rollers shall ensure that the cable does not scuff on the ground during pulling operation. The rollers must be cleaned and lubricated properly.

As per requirement of the field, the cables shall have to be laid in the followings (with prior approval of Employer):

- (a) In ducts / trench (trough)
- (b) In HDPE ducts / GI pipe
- (c) In air at terminations
- (d) At varying depths due to obstructions
- (e) As per approved drawings

At places where the cables crossroads, gates of residential houses or buildings, the cables shall be



laid in HDPE / GI pipes of adequate strength.

Laying of Underground power cable also includes laying of Underground Fibre Optic cable along with power cable in same trench.

Concrete trenches with precast covers may be used in exceptional cases in smaller portions, wherever bending of cables are involved and HDPE pipes can't be laid.

The arrangement of laying the cable route shall be submitted by Contractor during detailed engineering for Employer's acceptance. The Bidder shall also submit an inception report indicating detail description of procedure (Method Statement for Construction) to be deployed for laying of underground and fibre optic cable. The Contractor shall propose optimum cable sizing based on load current, voltage drop, short circuit current and protective device requirement and also to maintain reliable ring main 11 kV supply.

Any damage occurred to existing utility services during cable laying shall be brought to notice of relevant authorities and rectified immediately.

(2) Trenching

The trenching work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be restored to its original state.

Wherever possible sidewalks shall be used for the installation of cable. The trench shall be excavated using manual /mechanical modes as per field conditions. Most main roads are of asphalt surface and some of the roads with cement concrete surface. The sides of the excavated trenches shall, wherever required, be well shored up.

The trenching method shall be Open Digging or Horizontal Directional Digging (HDD). In several projects, heave and subsidence of road surface has been observed as a result of the excavation. The Contractor shall take appropriate precautions for the heave and subsidence of road surface.

Where paved footpaths, black topped roads or concrete slabs are encountered, the pavement slabs, roads shall be properly reinstated in original condition or better. Identification markers of other services shall be properly stored and reinstated. The excavated material shall be properly stored and filled back within 24 hours of excavation to avoid obstruction to public and traffic movement.

Suitable barriers should be erected between the cable trench and pedestrian/ motorway to prevent accidents. The barriers shall be painted with yellow and black or red and white colored cross stripes. Warning and caution boards should be consciously displayed. Red lights / light emitting signal as warning signal should be placed along the trench during the nights.

The bottom of the excavated trench should be levelled flat and free from any object which would damage the cables. Any gradient encountered shall be gradual. All cables shall only be laid directly onto the bottom of the trench, if the surface is unlikely to cause damage to the outer sheath and with prior approval of the Employer during detailed engineering. Where a sand bedding material needs to be used for the base of a trench, the depth of the trench shall be increased by the



appropriate amount to ensure that the required minimum depth of cover is achieved.

Following installation, cables shall be blinded to a compacted depth of 100mm above the cable or cable joint with soil taken from the excavated material or imported material.

The blinding shall be free from materials that may damage the cable. Imported material for blinding (sand) shall only be used if all the excavated material is unsuitable.

The Contractor shall remove from site all rubbish and salvaged materials. The whole area shall be left in a neat and tidy condition to the satisfaction of the Employer.

(3) Cable Trough

The cable trough and the cover shall be constructed using RCC of M20 grade.

The cable trough shall be designed for the following load.

- Dead load of 155 kg/m of cable support plus 75 kg on one tier at the end.
- Triangular earth pressure plus uniform surcharge pressure of 2 tons sq.meter.
- Cable trench covers shall be designed for (1) self-weight of top slab plus concentrated of 200 kg at center of span on each panel and a surcharge load of 2 tons per sq.meter.

The Contractor shall submit drawings and arrangements for Employer's approval.

(4) Cable Duct

The underground cables shall be installed in the cable ducts. HDPE pipe shall be used for HT and LT feeder cable, and PVC pipe shall be used for service cable for consumers.

(5) Trefoil/Flat formation

Cables shall be laid in trefoil/flat formation for the entire route. The Contractor shall submit drawings and arrangements for Employer's approval. If a single three core/triplex cable is installed, then the cable shall just be laid direct. If two or more 3 core cables are laid in the same trench then each cable needs to be horizontally separated by a minimum of 150mm.

(6) Cable handling

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in accordance with acceptable standard practices/statutory requirements.

(7) Damage to the property



The Contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damage so caused shall be immediately repaired and brought to the notice of the concerned and to the Employer. The Contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.

(8) Cable route makers/Cable joint makers

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings. Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface. The marker should incorporate the relevant information such that the name of the Employer, voltage, circuit and distance of cable from the marker.

(9) Depth of laying of cables

Depth of laying shall be as per IS: 1255. Laying at varying depths due to obstructions/site conditions may be accepted in extreme cases with prior approval of Employer during detailed engineering. The depth of underground FO cable shall be as per latest IS/IEC standards. However laying arrangement of Power cable and FO cable shall be finalized during detailed engineering.

(10) Paying out the cables

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The paying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension/ loading shall be monitored by tension indicator and shall not exceed the permissible value for the cable. The cable laying shall be performed continuously at a speed as recommended by manufacturer.

The cable end seals shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

(11) Sand bedding

The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage (applicable where cables are not to be laid in pipes / HDPE duct).

(12) Snaking

Snaking shall be done at necessary places recommended by manufacturer with prior approval of Employer.



(13) Thermal backfill

If specifically mentioned in Section-Project, Thermal Backfilling shall be carried out based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the Contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables. Thermal back fill shall be of thermal resistivity of 1.20 K.m/W or better.

(14) Immediate envelope to cable

The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the Employer. The Contractor shall seek prior approval on the use of the envelop material from the Employer before execution of the works.

(15) Backfilling

Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock shall be removed.

Backfill shall be placed in no greater than 20cm uplifts before compaction. Each uplift shall be thoroughly compacted before the following uplift is placed, Pneumatic or equivalent tampers shall be used on cohesive materials: vibratory compactors shall be used on noncohesive materials. Compaction shall achieve a density at least 95% of the maximum dry density of the surrounding undisturbed earth. Large stones or rock fragments may be used in the backfill provided they do not interfere with proper compaction. Particles larger than 25 cm shall be placed not nearer than 0.5 m of the structure and at least 1.0m below ground surface.

(16) Warning tape

A pre-warning, Red colour plastic/ PVC tape, of at least 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under CAUTION; EMPLOYER, VOLTAGE CLASS of CABLES. Protection concrete tiles shall also be used all along the route of the cable to protect the cables.

(17) Prevention of damage due to sharp edges

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench. Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius recommended by the manufacture.

(18) Road, Rail and Canal crossings

The road cutting, whether cement concrete asphalt or macadam road surface; canal crossing shall be taken up after obtaining approval for cutting/crossing from the concerned authorities i.e. office of the municipality, traffic police, telephone authorities, roads and water supply department etc., and work should be planned to be completed in the shortest possible time. Where necessary the work



shall be planned during night or light traffic periods. GI pipes shall be used for crossing. GI pipes diameter shall be as specified in the Technical Specification and Technical Particular.

(19) Trenchless digging

It is envisaged that trenchless digging shall be used for general cable laying. Additionally, crossing the National highways, Canals etc shall also be laid through HDD and the same shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T L.38. The various methods of trenchless digging such as hand/ manual auguring (up to 15m), impact moling (from 16m to about 40-50m), HDD (above 40-50m) shall be adopted based on the soil/site conditions and the requirement. The exact method for trenchless digging shall be finalised during detail engineering as per actual site/soil condition. The equipment used for HDD shall be capable of drilling at least 100 m at one go. The Contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer.

- (a) Excavation and backfilling of trial pits and verification of soil condition
- (b) Excavation of entry and Exit pits
- (c) Erection of drill machine for Drilling of pilot hole
- (d) Placement and driving hand augur
- (e) Placement and carrying out impact moling
- (f) Reaming and widening of bore holes in steps (if required)

Wherever Trenchless digging is adopted, the Contractor shall check the road surface conditions of the digging span prior to the excavation and shall make a record of the condition. After the excavation, the Contractor shall check the condition of road surface and shall make a record of the road condition.

During the excavation, the operator shall pay due attention to the condition of the road surface.

After the road pavement, the Contractor shall conduct a regular check to monitor the condition, and the results shall be reported to the Employer.

If the Contractor give damages the road surface condition, the Contractor shall take the responsibility of rectifying the road condition at the own expense, and restore it as soon as practical.

(20) Footpath cutting

The slabs, kerbstones, interlocking blocks, tiles, railing, tree guard etc. on the roads shall be removed and reinstated without damage. The Contractor shall ensure that all surfaces make smooth junction with existing works. In case of damages they have to be replaced by new ones.

(21) Reinstatement

After the cables and pipes have been laid and before the trench is backfilled all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken



over by the Engineer in charge. The protective covers shall then be provided, the excavated soil riddled, sieved and replaced. It is advisable to leave a crown of earth not less than 50 mm and not more than 100 mm in the centre and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently in rainy season and immediately after overnight rain for checking settlement and if required the temporary reinstatement should be done.

After the subsidence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

(22) Tools and plants

The successful bidder shall arrange, at his own cost, all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal, to carry out the work successfully and speedily.

(23) Bending radius

The cables shall be treated with according to manufacturer's recommendation. Any overstress due to over-bending, excess pulling must be avoided. The minimum bending radius of XLPE insulated cables shall be $20XD$ where "D" means the Outer diameter of the cable.

(24) Jointing and termination of cables

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends. The cable ends shall be protected all the times with heat shrink end caps.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.

Cable overlap of at least 1.5 m shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

(25) Sump holes

When jointing cables in water logged ground or under unforeseen rainy conditions, a sump hole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or taken out by buckets, without causing interference to the jointing operation.



(26) Tents/Covers

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. Joints shall be made in as clean an environment as practicable.

(27) Precaution before making a joint

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

(28) Measurement of insulation resistance

Before jointing, the insulation resistance of both sections of cables shall be checked.

(29) Identification

The identification of each phase shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

(30) Making a joint

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing XLPE cables.

All cable joints and terminations must be carried out by qualified personnel. The cable jointers must be in possession of a valid trade certificate for jointing works from a recognized institution. CVs of cable jointers shall be approved by Employer prior to commencement of works.

(31) Cable laying and Termination

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed. Cables shall be terminated at RMU, Distribution Transformers, Switches or LT distribution boxes.

At cable terminating end, the following provisions for supply and erections are to be included:

- (i) A sufficient length of spare cable shall be left in the ground, for future needs.



- (ii) The rise of the cable immediately from the ground shall be enclosed in PVC/PE/GI pipe of suitable diameter to protect against direct exposure to the sun.
- (iii) The cable shall be properly fastened using non-metallic clamps.
- (iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.

(32) Bonding of screens

The cable earth screens shall be bonded to earth at the termination positions.

(33) Connection of radial water barrier and cable screen

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

(34) Measurement (for civil works)

The measurement of the buried cable trench—including excavation, backfilling, thermal backfilling (if applicable), sand filling, compaction, and the laying of concrete or reinforcement—shall be conducted in accordance with the drawings and specifications to ensure successful completion of the work, and shall follow the Price Schedule.

(35) Optical Fiber cable (for communication equipment)

Optical Fiber cable required for Communication Equipment shall also be laid in the same cable trench in separate HDPE pipe.

(36) Miscellaneous

All the civil works associated with laying of underground cable are described in Civil Works.

2.7.2 CABLE TERMINATION AND JOINT

(1) General requirements

This specification covers the design, manufacture, factory test, supply and delivery of heat shrinkable type termination and joint kits for 11 kV, 3 core screened, armoured, with aluminum conductor XLPE cables suitable for earthed system and conforming to relevant standard with latest amendment, if any.

The termination kits for the use on 50 Hz, 3 phase system with earthed neutral for working voltage of 11 KV.

The Termination kit and jointing kit shall be heat shrinkable if not specified otherwise in either section GTP or Price schedule



All high voltage termination and jointing kits shall be standard quality type. They shall be factory engineered kits containing all the necessary components to reinstate the cable insulation, metallic shielding of each core, together with the reinstatement of the sheath and of the cable being terminated.

The heat shrinkable termination and joint kit shall be manufactured and tested in accordance latest version of IEC, or any other national or international standard that ensures at least a substantially equal quality to the standard.

The manufacturer of the termination and joint kit (Indoor, outdoor and straight- through) must have been accredited with ISO 9001 quality certification. The heat shrinkable terminations offered shall be of proven design and make, which have already been extensively used and fully type tested.

The entire termination and joint kit shall be environmentally sealed and capable of preventing the ingress of external moisture and contamination.

Kits shall contain sufficient cleaning solvents and cleaning clothes for the proper making of the joint or termination.

Voltage stress relief shall be provided and this may be inherent in the heat recoverable polymeric material.

The terminating or jointing materials shall not be subjected to storage limitations such as controlled temperature or humidity restrictions, nor have shelf life limitations.

(2) Other requirements

The outdoor termination kits shall be suitable for terminating the cable at steel cross arm complete with brackets, terminals, saddles and all necessary materials for fixing the termination. The heat shrinkable termination kit to be supplied and installed under this scope of work shall be capable enough to cope with all the weather change.

Terminations that do not require manually built stress relief cones or field pouring compound are preferred.

The term heat shrinkable refers to extruded or moulded polymeric materials which are cross-linked to develop elastic memory and supplied in expanded or otherwise deformed size/shape, subsequently heating in a non-constrained state to a temperature above the shrink temperature resulting in the material recovering or shrinking to its original shape.

Since the sealant or adhesives (to be used for environment sealing) between the heat shrinkable materials and XLPE cables shall be exposed to high electrical stresses, they must be track resistant.

The heat shrinkable polymer materials being used for external leakage insulation between the high voltage of conductors and grounds should be weather resistant.



All cuts/nicks inadvertently occurred to XLPE insulation must be rendered discharge free by using suitable discharge suppression compound.

The heat shrinkable tubing may be either extruded or moulded type.

Higher thickness of heat shrinkable sleeves shall be preferable to counter erosion due to pollution.

Rubber components should be made from proven quality of tuber with tested curing properties.

The semi conducting portion of the stress cone should be vulcanized with insulation so that both semi conducting and insulation portion becomes an integrated part.

The stress cone must be of proven design of stress control.

The moulding of rubber components should be aimed to achieve a smooth finish on interior and exterior of the components.

In case of outdoor terminations, the suitable provision for covering the cable cores with re-useable protective system from the crotch seal to the bottom of stress cone should be made.

Accessories shall match the cable test ratings in all respects. The material and components not specifically stated in the specification, but which are essential for satisfactory operation of the equipment shall be included without any extra cost.

The termination and joint kits shall be of suitable for following cables:

- Outdoor and Indoor use for 11 kV, 3-cores Aluminum XLPE insulated Power cables.

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CHAPTER 3:

OVERHEAD CONDUCTOR AND CABLE



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CHAPTER 3: Overhead Conductor and Cable

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
3.1	General	1
3.2	XLPE Covered All Aluminum Alloy Conductor.....	1
3.2.1	General Requirements.....	1
3.2.2	Description.....	1
3.2.3	Inspection and Tests	4
3.2.4	Verification of Length of Conductor	6
3.3	Aluminium Conductor Steel Reinforced	6
3.3.1	Scope.....	6
3.3.2	Description.....	6
3.3.3	Packaging	7
3.3.4	Tests	7
3.4	Accessories for XLPE INSULATED AAAC	8
3.4.1	General Requirements.....	8
3.4.2	Type of Accessories	8
3.4.3	Description.....	8
3.5	LV Aerial Bundled Conductor (ABC)	11
3.5.1	General Requirements.....	11
3.5.2	Description.....	12
3.5.3	Testing	13
3.6	Accessories for LV Aerial Bundled Conductor (ABC)	13
3.6.1	General Requirements.....	13
3.6.2	Testing	15



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3.1 GENERAL

The specification covers design, manufacture, testing before dispatch, transportation, supply and delivery of Overhead conductors, cables and the accessories.

XLPE covered All Aluminium Alloy Conductor (AAAC) shall be used for the construction of 11 kV, 3 phase distribution system.

Aluminium Conductor Steel Reinforced (ACSR) conductor shall be used for the span of the steel lattice tower.

0.6/1 kV cross-linked polyethylene (XLPE) insulated with insulated neutral messenger conductor supporting aerial bundled conductor (ABC) shall be used for the construction of 400/230 V, 3 phase, 1-neutral distribution system.

The standards to be applied for design, manufacture and tests of cables and accessories shall be the following IEC Recommendations and/or equivalent internationally recognized standards.

IS 8130-1984	:	Specification for Conductor for Insulated Cable En 50397-1
IS 7098(P-1) /1988	:	XLPE Insulation
IS 398 (Part-IV)	:	Specification for Aluminum Alloy
IS 10418 /1982	:	Drum for Electric Cables
IS 398	:	Aluminium Conductor for overhead Transmission Purpose

3.2 XLPE COVERED ALL ALUMINUM ALLOY CONDUCTOR

3.2.1 General Requirements

XLPE covered All Aluminum Alloy Conductor (AAAC) are preferred than conventional HT overhead line with bare conductors as those are not subjected to frequent faults as happens with the bare conductors, to minimize problem of tree clearance and in some cases where it is difficult to get clearance for bare conductor lines.

The cable shall be suitable for installing in the climate conditions.

Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

Each core shall be identifiable throughout the either by colour or numbering.

Repaired cables shall not be accepted.

Outer layer colour shall be black.

3.2.2 Description

- (1) Conductor



The conductor shall be of multi-strand round compacted hard drawn aluminum alloy conforming to the specified standards.

The properties of stranded aluminum conductors of various size shall be as below:

SE. No.	Description	Unit	100 mm ² conductor
1	Actual Area	mm ²	100
2	Stranding & wire diameter	mm	7/4.26
3	Approximate overall diameter	mm	12.78
4	Approximate weight	kg/km	272.86
5	Maximum calculated D.C. resistance at 20 degree C	Ω/km	0.3390
6	Approximate calculated breaking load	kN	29.26
7	Reactance per km	Ω	0.3394
8	Current Rating	Amps	325

The properties of aluminum alloy wires to be used in the construction of the stranded conductors shall be as below:

Se. No.	Description	Unit	100 mm ² Conductor
1	Nominal Diameter	mm	4.26
2	Maximum Diameter	mm	4.3
3	Cross-section area of nominal diameter wire	mm ²	14.250
4	Weight	kg/km	38.48
5	Maximum Calculated D.C. resistance at 20 degree C	Ω/km	2.345
6	Minimum breaking load after stranding	kN	4.18

No negative tolerance shall be permitted on the nominal diameter aluminum wire used in the manufacture of AAAC XLPE Covered Conductor. However, positive tolerance in this respect shall be as provided in IS: 398 (Part IV) -1994 (amended up to date) or equivalent standards.

(2) Insulation

The Insulation should be dual layered with the Inner Layer being XLPE with a nominal thickness of 1.2 mm for Voltages up to 11 and the Outer Layer being a suitable XLPE which is UV Resistant, Non-Tracking and Erosion Resistant with a nominal wall thickness of 1.1 mm. The minimum combined Insulation Thickness of both Layers should be 2.0 mm.

The conductor's manufacturing and stranding process shall incorporate the longitudinal water blocking also.

The Semi Conducting Screen, Inner Insulation and Outer Insulation should be extruded in one step i.e. triple extrusion to ensure a good, permanent bond between the three layers and also with the conductor.

It shall be possible to remove the Semi Conducting Screen, Inner and Outer Insulation Layers without damage to the conductor

(3) Filling (Water blocking)

Suitable water blocking material shall be incorporated between the conductor and the covering during the extrusion process to prevent the migration of water along the conductor. The water blocking material shall be of contrasting colour to that of the conductor. The water blocking material shall not affect the interstrand conduction and also not affect the adhesion between the conductor

and the XLPE cover. Water blocking material shall be stable at maximum operating temperature of 80 degree Celsius and full technical particulars with regard to the above shall be furnished with the offer.

(4) Freedom from Defects

The wire shall be smooth and free from all imperfections such as spills, splits, slag inclusion, diameter marks scratches, fittings, blow holes, projections, looseness, overlapping of strands, chipping of aluminum layers etc. And all such other defects which may hamper the mechanical and electrical properties of the conductor. Special care should be taken to keep away dirt, grit etc. during stranding.

(5) Joints in Wires

There shall be no joint in any wire of a stranded conductor containing seven wires, except those made in the base rod or wire before final drawing.

(6) Stranding

The wires used in the construction of a stranded conductor shall, before stranding satisfy all the relevant requirements of this standard.

The lay ratio of the different layers shall be between 10 and 14.

In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded.

(7) Marking on Cable

The outer protective sheath of the cables shall carry the following indications:

- Name of Manufacturer
- The year of manufacture
- The rated voltage
- An indication of the insulation
- Cross section of the phase conductor cores

(8) Packaging

The finished covered conductors shall be delivered in continuous lengths of ± 5 meters from the specified length and the ends of the covered conductors shall be effectively sealed with heat shrinkable cap to prevent ingress of moisture. The conductor shall be wound to the drum with the lowest number at the inner end of the drum. They shall be supplied in wooden drums made of well-seasoned wood that is treated to prevent deterioration by termites or fungus attack and suitable for outdoor storage of twelve (12) months or steel drums. The chemical used for treating the wood shall not be harmful to the conductor and the drum shall be lined with an impervious material to prevent direct contact of the covered conductor with the drum.

The external flange diameter shall be such that the distance between the outer edge of the flange and the packed conductor shall not be less than 75mm so that the drum could be rolled on the flanges without causing damage to the conductor. Direction of rolling shall be clearly marked.

The drum shall have spindle hole of adequate diameter and reinforced with steel plates for mounting the drum on horizontal axle for laying out the conductor.



Each reel of the conductors furnished shall contain only one (1) length of conductor.

All reels shall be legibly marked in paint with the following information:

- (a) Size of conductor
- (b) Type of conductor
- (c) Length in meters
- (d) Net weight of conductor
- (e) Direction of rolling

The standard length of the completed cover conductor in each reel shall be 1.0 km

3.2.3 Inspection and Tests

(1) Type Tests

Type Test reports not older than 7 years of at least two sizes of Covered Conductor as specified in relevant IS & IEC conducted from independent recognized laboratory accredited ILAC/IAF shall be furnished along with the Bid.

The type test reports shall contain details of following tests as per IS 8130 - 1984 and EN 50397-1:2006 (or equivalent standard).

- (a) Electrical Tests
 - (i) Conductor resistance
 - (ii) High Voltage Test
 - (iii) Spark test on the covering
 - (iv) Test Voltage: AC 0.7U or DC 1U
 - (v) Leakage Current
 - (vi) Test Voltage: AC 0.7U
 - (vii) Tracking Resistance
- (b) Construction and Dimensions
 - (i) Compliance with the design's requirements
 - (ii) Thickness of the covering
- (c) Construction and Dimensions
 - (i) Tensile Strength and Elongation at break
 - (ii) Resistance to UV rays
- (d) Non-electrical tests on the covering
 - (i) Mechanical
 - Sample properties before aging
 - Sample properties after aging



- (ii) Carbon black content
- (e) Tests on compatibility
 - Aging of complete product sample
- (f) Thermal properties of the covering
 - (i) Shrinkage test
 - Distance between marks: 200 $\pm$ 5mm
 - (ii) Hot-set-test
 - (iii) Pressure test at high temperature
- (g) Further test on the covering
 - (i) Water absorption
 - (ii) Shore hardness
- (h) Test of the longitudinal water tightness
 - (i) With heat cycle

Number of specimens	1
Length of specimen	3m
Test duration	24 h
Bending radius	20 D

- (ii) Without heat cycle

Number of specimens	1
Length of specimen	3m
Test duration	24 h

- (i) Marking
 - (i) Content, Legibility
 - (ii) Durability
- (j) Slippage Test

(2) Routine Tests

All the routine tests as per IS 8130/1984, En 50397-1: 2006, IS 7098 (P-1) /1988 and IS 398 (Part-IV) amended up to date shall be carried out on each and every delivery length. The result shall be given in test report and be submitted to the inspectors at the time of pre-dispatch inspection test.

(3) Acceptance Tests

All the acceptance tests as per IS 8130 1984, En 50397-1: 2006, IS 7098 (P-1) /1988 and IS 398 (Part-IV) amended up to date shall be carried out on each and every delivery length.

(4) Other tests

Type test / acceptance test / routine tests and any other tests not covered as stated in different clauses of the specification but required as per relevant standards shall also to be carried out.

(5) Inspection



All tests (except type test) and inspection shall be made at the place of manufacturer unless otherwise especially agreed upon by the manufacturer and purchaser at the time of purchase. The manufacturer shall provide the inspector representing the purchaser all reasonable facilities without charges, to satisfy him that the material is being furnished in accordance with this specification.

3.2.4 Verification of Length of Conductor

The Purchaser shall ascertain the length of AAA COVERED Conductor at supplier's works and at the receiving store centers by measuring the actual length by length measuring machine used for the purpose. The supplier should ensure that length measuring machine is available for measurement of the length by our inspecting officer.

Both ends of the AAA COVERED Conductor shall be sealed by the supplier and seals will be contained in the drum and not exposed out of drum.

The declared length will be measured between manufacturer's seals at both ends of AAA COVERED Conductor.

The weight of AAA COVERED Conductor will also be checked for ensuring correct lay and length of the AAA COVERED Conductor.

For the verification of the length of the conductor, 10 %of total lot (in Drums) should be selected at the works. The physical verification of the length of the conductor should be carried out for maximum up to 5 (five) drums. If there are any more drums left for verification, then weight of each verified drum should be carried out and average weight may be calculated.

Then the weight of each of all the remaining selected drums may be taken and if these weights are matching with the average weight, then that particular lot may be accepted otherwise rejected.

Verification of length of conductor will also be carried out at each stores center for two drums out of each lot. If the average length is found correct or more, the lot will be accepted. If the average length is found to be less than the declared, the percentage of such short length will be applied for reduction for the entire quantity supplied in the lot at respective stores for acceptance.

3.3 ALUMINIUM CONDUCTOR STEEL REINFORCED

3.3.1 Scope

This Specification covers the fabrication and supply of aluminum conductors, steel reinforced (ACSR) commonly used on overhead power line construction.

3.3.2 Description

The manufacturer of the ACSR conductor must have been accredited with ISO quality certification.

The ACSR conductor shall be a concentrically stranded right-hand lay conductor.

The ACSR conductor shall be fabricated in accordance with IS: 398 or any other international standards that ensures a substantially equal quality to the standard mentioned above, will also be acceptable.

The following types of conductors shall be supplied:



Se.No.	Description	Unit	ACSR 'DOG' Conductor
1	Nominal Aluminum Area	mm ²	100
2	Stranding	Al/Steel	6/7
3	Wire Diameter		
	Aluminum	mm	4.72
	Steel	mm	1.57
4	Overall Sectional Area		
	Aluminum	mm ²	105.0
	Steel	mm ²	13.50
	Total	mm ²	118.5
5	Overall Diameter of Conductor	mm	14.15
6	Approximate Mass	kg/km	394
7	Calculated Resistance at 20 degree C	Ω/km	0.27
8	Breaking Load	kN	32.41

3.3.3 Packaging

The packaging of goods shall be in accordance with IS:398. All conductors shall be furnished on non-returnable steel drums/reels. Protective external lagging of sufficient thickness shall be provided and fitted closely on the reels. Binder consisting of steel straps shall be provided over the external laggings. The reel shall be new and sufficiently sturdy in construction to withstand ocean shipping, road transport, several loading and unloading, storage in tropics, hauling and field erection of conductor without distortion or disintegration.

Each reel/drum of the conductors furnished shall contain only one (1) length of conductor.

All reels shall be legibly marked in paint with the following information:

- (a) Size of conductor
- (b) Type of conductor
- (c) Length in meters
- (d) Net weight of conductor
- (e) Direction of rolling

The standard non-joined length of the completed conductor in each drum/reel shall be as below:

Conductor	ACSR 'DOG'
Standard non-joined Length in each drum (m)	500

3.3.4 Tests

The manufactured conductor shall be tested in full compliance with the governing standard including following routine tests:

- (1) Aluminum wire:
 - (a) Tensile test
 - (b) Wrapping Test



- (c) Resistivity Test
- (2) Steel Wire
 - (a) Determination of stress at 1% elongation
 - (b) Tensile test
 - (c) Torsion test or elongation test as appropriate
 - (d) Wrapping test
 - (e) Galvanization test
 - (f) Ductility test

3.4 ACCESSORIES FOR XLPE INSULATED AAAC

3.4.1 General Requirements

The joint & terminations shall be suitable for the covered conductor for which they are designed. The joint shall have the same basic insulation properties as the conductor covering. In this case, the test shall be carried out according to EN 50397-1 table 2, ref. 1.2 "High Voltage (HV) test". The conductor shall have a sufficient length so that the joint is immersed and the test duration shall be same as for sample test.

Applicable Standards for Manufacturing fitting for XLPE Insulated AAAC.

EN 50397-1 (2006)	:	Covered Conductor Specification up to 33 kV
EN 50379-2 (2009)	:	Accessories for covered conductors' specifications, tests and acceptance criteria
EN 50392-29 (MARCH 2010)	:	Covered conductors for overhead line and related accessories for rated voltage above 1 kV A.C. and not exceeding 33kV A.C.

3.4.2 Type of Accessories

Se. No.	Description	Application
1	Tension Assembly (TA)	For fitting onto a pole for tensioning at the beginning or end of a length of MVCC, or for anchoring while a major change in direction. The Tension assembly consists of one wedge type Tension/anchoring clamp and one Tracking protection IPC
2	Suspension Clamp (SC)	For supporting a length of MVCC at an intermediate pole in a length, with large angle of deviation with a disc insulator. The suspension clamp consists of an "Assembly with one locking type Suspension clamp with provision to fix in Insulators.
3	Connection of Bare to Covered	A suitable size of lug for bare conductor and termination kit for MVCC connection
4	Full Tension Joints (TJ)	Mid-span full tension joints for jointing MVCC over a span. A suitable size of lug for bare conductor and termination kit for MVCC connection.

3.4.3 Description

- (1) Tension / Anchoring Clamp

Anchoring assemblies are used to firmly hold the MVCC (Medium Voltage Covered Conductor) to a concrete or steel pole and transmit the mechanical tension.



At the end of a run

At a major change in direction of over 20 degrees.

The clamp should consist of an Aluminum alloy corrosion resistant body, Rigid sling ("bail") of stainless steel with Tracking insulation piercing connector and self-adjusting plastic wedges which shall anchor/hold the cable.

The following key criterion to be followed for the design of the same

- (a) There shall be no losable part (except bail) in the process of clamping arrangement
 - (b) Locking mechanism should be wedge type self-locking. Wedges are to be made of high strength, frost, heat and UV-radiation resistant plastic with glass fiber.
 - (c) The fittings shall be able to withstand the specific minimum failure load (SMFL) and shall not damage the covering. The SMFL is the minimum load 20KN for 50-70 sq mm and 28KN for 95-157 sq mm.
 - (d) Tracking insulation piercing connector shall be made of aluminum and having multiple teeth. The insulation piercing connector shall be supported by both side of rigid bail to ensure proper fixing and shall have aluminum alloy shear head to ensure proper tightening at all working temperatures.
- (2) Rigid Sling (Bail) of Anchor Assembly

The Anchoring assembly shall be supplied with a stainless-steel rod to connect the Tension Clamp to the Insulator lamp on the pole.

The Rigid Bail forming part of clamp should have sufficient distance (minimum 300 mm) between bracket and body of clamp and shall have sufficient mechanical strength to withstand the mechanical test for the complete assembly tests in this specification. Flexible bail is not acceptable due to the reason to withstand the load. Rigid Bail should be fitted with provision to remove from the clamp to have easy installation.

(3) Wedge Type Tension Clamp for Anchoring Assembly

Wedge type clamps shall be used for clamping the MVCC without damaging the insulation and shall be capable of clamping an uncut MVCC so that it can continue without break to the connection point of next span.

The clamp shall be of aluminum with fully insulating type of mechanical and weather resisting thermoplastic wedges.

No tools shall be needed for fitting the MVCC into the clamp.

The wedge shall be connected to fitting the MCVV into the clamp

The wedge shall be connected to insulation piercing connector and connector shall move with wedge movement. The fitting shall be able to withstand the specific minimum failure load (SMFL) and shall not damage the covering and shall be designed to prevent the ingress of moisture during service.

Covered conductor size	SFML	Tightening Torque for connector	Minimum weight requirement
100 sq mm	20-28 kN	22-30 Nm	2.4 kgs (min)



(4) Suspension clamps

The suspension clamps shall be made of corrosion resistant aluminum alloy and to avoid any insulation damage to covered due abrasion while mechanical or wind vibration.

The suspension clamps shall be made of corrosion resistant aluminum alloy and to avoid any insulation damage to covered conductor due abrasion while mechanical or wind induce vibration.

The clamp should be suitable to accommodate from 50 to 157 sq mm cable size.

The suspension clamp should be suitable for angles up to 90°.

The SMFL load should be minimum 30KN

The suspension clamp should be tested in accordance with EN50397-2 standard

Suspension should have minimum bolt 16mm and should be equipped with Aluminum alloy shear head bolts with tightening torque as 40Nm

Bolt and side frame shall be hot dip galvanized

The clamp should have an in-built insulation piercing contact

Insulation piercing connector part should have a silicone seal which prevents the moisture getting into the conductor.

The insulation piercing clamp piece should be connected to the body with a wire for balancing the potential.

The suspension clamp should be tested for radio interference.

The suspension clamp should not have loose parts, so it is easy to handle even in difficult conditions.

Suspension clamp should be with a pulley for covered conductors to ensure removing requirement of additional separate installation pulley.

The clamp shall have provision to accommodate conductor joints with diameter under 30mm can be pulled through the suspension clamp.

Covered conductor size	SFML	Tightening Torque for connector	Minimum weight requirement
100 sq mm	20-28 kN	20-30 Nm	2.4 kN

(5) Mid Span full tension automatic joints

The mid span Insulated jointing sleeves shall be of the tubular type, suitable for making full tension joint between two conductors of same size, it shall be provided with a center stop "indent" for correction positioning of the conductors to be joined.

The tensile strength of the mid span jointing sleeve after crimping/compression shall not be less than 95% of the strength of the covered conductors. Heat shrinkable insulation tubing of adequate length shall be provided.

The jointing sleeves shall be pre-filled with any suitable oxide inhibiting compound and their current rating shall not be less than that of the covered conductors.



- (a) The joint should be as per standard EN 50397-2
- (b) The joint should be the automatic joint to ensure easy and quick to make.
- (c) No tools are needed for the installation. The design must be push in and made type
- (d) The joint shall be color coded for easy to find the correct size.
- (e) The joint shall have strong wedge to ensure a safe joint.
- (f) Joint shall have insulation cold shrink sleeve tubing for tool free operation
- (g) Reference standard, type test and design requirements of EN Standard 50397-2
- (h) The joint shall have the same basic insulation properties as the conductor covering.

In this case, the test shall be carried out according to EN50397-1, Table 2, ref.1.2 "High voltage test".

(6) Insulation End Cap

The Insulated End Cap shall be suitable for effectively sealing the end terminal of the covered conductors. The inner diameter range of the cap shall be such that it shall tightly fit to the covered conductors to prevent entry of moisture.

- (a) Cap shall be made of elastomer material
- (b) Cap shall accommodate the conductor size
- (c) No tool is required for the sealing end cap installation
- (d) It shall be tested for 11kv working voltage

(7) Marking

The covered conductors shall carry the following marking as per EN 50397-1 or as agreed.

All products mentioned above shall permanently bear:

- (a) Manufacturer's trade mark or logo
- (b) Product code / batch code and manufacturing period (MM-YY) is to be marked;
- (c) The minimum and maximum cross section for which the unit is suitable
- (d) Tightening torque or die reference, if applicable.

3.5 LV AERIAL BUNDLED CONDUCTOR (ABC)

3.5.1 General Requirements

This Specification covers the design, manufacture, factory test and supply of 0.6/1 kV cross-linked polyethylene (XLPE) insulated with insulated neutral messenger conductor supporting aerial bundled conductors (ABC) for use in the construction of 400/230V, 3-phase, 1-neutral, 1-street lighting, distribution systems.

The cable shall be manufactured and tested in accordance with relevant IEC or latest revision



thereof or any recognized international standards that ensures at least a substantially equal quality to the standards mentioned above.

The ABC shall be insulated aluminum neutral messenger conductor supported type.

The complete cable shall consist of five insulated conductors stranded together, and the direction of lay shall be right-hand. The type of construction shall cause the tensile load to be shared equally between conductors.

3.5.2 Description

(1) Conductors

The conductor shall consist of compact round stranded aluminum wires.

The phase conductor shall be of multi-strand round compact hard drawn aluminum conforming to IEC 61089 with XLPE insulation.

(2) Insulation

The conductor shall be insulated by extruded black cross-linked polyethylene (XLPE) material.

The outer covering of the R phase of the cable shall be embossed with name of the manufacturer, name of the Purchaser "NEA", the cross sections, type of insulation followed by "Electric Cable: 600/1100 Volts" at the spacing of 5 meters. Every 2 meters of outer covering of the cable shall also be embossed with length of the cable.

(3) Messenger wire

The neutral messenger conductor shall be of multi-strand round compact hard drawn aluminum conforming to IEC 61089 with XLPE insulation.

(4) Phase Identification

The identification of the conductors shall be provided by means of ribbing on the external surface of the insulation. R, Y and B phase conductors shall have one, two, and three ribs respectively. Space between the ribs in R, Y and B phases shall be 5 mm. Ribs shall be in rounded form. The neutral messenger conductor shall be plain without any ribs.

(5) Packaging

Each reel of the conductors furnished shall contain only one (1) length of conductor.

All conductors shall be furnished on non-returnable seasoned wooden reels or steel suitably protected against corrosion. All timber shall be treated to provide protection against rot and insects. Protective external lagging of sufficient thickness shall be provided and fitted closely on the reels. Binder consisting of steel straps shall be provided over the external laggings. The reel shall be new and sufficiently sturdy in construction to withstand ocean shipping, road transport, several loading and unloading, storage in tropics, hauling and field erection of conductor without distortion or disintegration. The treatment process shall not have deleterious effect on the cable.

Before dispatch, the ends of the bundled conductors shall be sealed to prevent moisture ingress during transportation and storage. Both ends of every length of the assembled bundle shall be temporarily bound in such a manner as to prevent cores from separating.

All reels shall be legibly marked in paint with the following information:



- (a) Type of conductor
- (b) Size of conductor
- (c) Voltage
- (d) Length in meters
- (e) Net weight of conductor and Drum Separately
- (f) Direction of rolling

The standard length of the completed conductor in each reel shall be finalized during detailed engineering. Indicative length is as per the table below:

Cable Size (sq. mm)	:	120 & 95
Normal Length of the Conductor (m)	:	500

3.5.3 Testing

All cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & type test reports shall be submitted for Employer's approval.

3.6 ACCESSORIES FOR LV AERIAL BUNDLED CONDUCTOR (ABC)

3.6.1 General Requirements

The fittings, hardware and equipment shall be fabricated in accordance with International recognized standards such as IEC, NFC for Fittings and Associated Apparatus for use with LV ABC of latest revision, and all referenced standards therein, or latest revision thereof or other recognized international standards that ensures at least a substantially equal quality to the standard mentioned above, will also be acceptable.

The fittings shall be for use in conjunction with insulated neutral messenger 3-core phase, 1-core neutral messenger and 1-core public lighting ABC of all size of cables.

Contractor shall get approval of all drawings and hardware sample from Purchaser before starting the fabrication of all hardware.

The fittings and accessories area as follows:

- (1) Anchor clamp with bracket

The clamps should be designed to anchor insulated messenger of LV ABC.

The clamp should consist of an aluminum alloy corrosion resistant body, bail of stainless steel and self-adjusting plastic wedges which shall anchor/hold the neutral messenger without damaging the insulation.

The clamp should be installed properly with no losable part. It shall conform to the standard NFC33-041 or equivalent other international standards. The clamp body should be made of corrosion resistant aluminum alloy, bail should be of stainless steel to prevent from corrosion & climatic variations, a plastic saddle should be installed on the flexible bail to limit abrasion with hook/bracket and wedges should be of weather and UV resistant polymer. It should be fixed with pole by eye hook/bracket. Bracket should be made of corrosion resistant aluminum alloy.



(2) Suspension clamps with bracket

The clamp should be designed to hang LV ABC with insulated neutral messengers. The neutral messengers should be fixed by an adjustable grip device. A movable link should allow longitudinal and transversal movement of the clamp body.

The suspension clamp range to accommodate messenger shall be 25- 95mm². The clamp should be installed properly with no losable parts. The clamp shall conform to the standard NFC33-040 or other equivalent international standards. The clamp and movable link made of weather and UV resistant thermoplastic polymer should provide additional insulation between the cable and the pole. The clamps and the movable links should be made of weather and UV resistant thermoplastic polymer. Clamps should be fixed with pole by eye hook/bracket. Bracket should be made of corrosion resistant aluminum alloy. The Suspension Clamp & the bracket will be preferably delivered together in order to minimize abrasion between two materials.

Ultimate Tensile Strength of the clamp should not be less than 12 KN for 25- 95 sq.mm insulated messenger wire. Maximum Allowable load of the clamp should not be less than 12 KN for 25-95 sq.mm insulated messenger wire.

Slip load of the clamp should not be less than 300N for 25-95 sq.mm insulated messenger wire. The clamp should sustain to maximum angle of deviation of 60 degrees of the conductors.

(3) Insulated cable end caps

The insulated cable end caps shall be made of weather and age resistant insulating material and shall have wet flashover voltage not less than 6 kV.

The cap shall be heat shrinkable type or without heat shrinkable and shall be coated internally with a suitable sealant. The caps shall be suitable for all sizes of ABC.

(4) Insulated insulation piercing connectors (IPC)

The insulated insulation piercing connector (or the connector for short) shall be suitable for using with aluminum ABC and concentric cables. It shall be made of high quality, weather, heat and age resistant insulating material having wet flashover voltage not less than 6 kV. It shall be watertight and suitable for making connections to the live lines. The piercing of main line and the tapping shall be done simultaneously. The design of the connectors shall be such that its removal is possible even after breaking of the shear head.

The connector shall be provided with end cap for tapping end. The IPCs for the network application (Type A) shall be preferably of two bolt type and service application (Type B) shall be preferably of single bolt type. The IPCs for the network application shall withstand at least 5 kA fault current for 1s without damage. The connector shall be suitable for following cables.

Type	Main	Tapping
Type A	50-120 sq. mm, ABC	500
Type B	50-120 sq. mm, ABC	6-25 sq.mm, ABC/Concentric cable

(5) Core separator (pairs)

The core separators shall essentially comprise two wedges to facilitate the installation of connectors on tensioned ABC cable. The two separators shall be joined together with a nylon cord. The two separators, which shall be made from either hardwood or rigid plastic, shall be so shaped as to be capable of being positively locked in position.



(6) Jointing sleeves

The joint should be Pre-Insulated for Phases, neutral messengers and Street Lighting conductors. Sleeve should be made of Aluminum, insulated with an anti UV black thermoplastic tube hermetically sealed two ends with 2 flexible rings to prevent water penetration. The sleeves shall be water tight with wet flashover voltage not less than 6kV upon installation.

(7) Stainless Steel Strap and Buckle

The stainless steel strap shall be of 20x0.7mm size and be supplied in a roll of 50 m. The breaking strength of the strap shall be at least 0.95 kN/mm²

(8) Stainless Steel Strap Binding Tool

The strap binding tool shall be of ratchet type to be operated by the lines men by hand while working on the poles.

3.6.2 Testing

The tests shall comply with relevant IEC Standard or the governing standard & type test reports shall be submitted for Employer's approval.

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CHAPTER 4:

CONDUITS, TRENCH AND HANDHOLE



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CHAPTER 4: Conduits, Trench and Handhole

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
4.1	HDPE Pipe	1
4.1.1	General	1
4.1.2	Description	1
4.1.3	Accessories	1
4.1.4	Technical Requirements for HDPE Pipe	1
4.1.5	Test	2
4.2	PLB HDPE Pipe	2
4.2.1	General	2
4.2.2	Construction of PLB HDPE Pipe	2
4.2.3	Standards	2
4.2.4	Material	3
4.2.5	Dimension of pipe	4
4.2.6	Accessories of PLB HDPE Pipe	4
4.2.7	Workmanship	4
4.2.8	Marking	5
4.2.9	Installation of Underground Fiber Optic Cable System	5
4.2.10	Survey	5
4.2.11	Installation of PLB HDPE Pipe	7
4.2.12	Acceptance Testing of PLB HDPE Pipes	8
4.2.13	Type Testing	8
4.2.14	Factory Acceptance Test	8
4.2.15	Site Acceptance Test	8
4.3	PVC Pipe for Service Cable	9
4.3.1	General	9
4.3.2	Construction of PVC Pipe	9
4.3.3	Standards	9
4.3.4	Specification	9
4.4	Handholes	10
4.4.1	Site Acceptance Test	11
4.5	Cable Trough (Trench)	12
4.6	GI Pipe	13



4.7	Truss Bridge for canal Crossing.....	14
4.8	Cable Raceway.....	16
4.9	As Built Drawings/Details	16
4.9.1	Documentation.....	16
4.10	Miscellaneous Works	17



4.1 HDPE PIPE

4.1.1 General

This Specification covers the fabrication and supply of 160 mm and 125mm (outer diameter) HDPE Pipe used for XLPE power cable in underground 11kV and LV distribution system.

4.1.2 Description

The HDPE pipes are black and should be suitable for inserting cables. The flexible conduit pipe shall be plain pipe shall be used for installation of XLPE power cable. The pipe shall be buried before the cable installation, and then the cables shall be pulled in. The HDPE pipe material should be Fire Retardant or non-Flammable.

The HDPE pipes shall be fabricated and tested in accordance with BS: 3412 and IS 4984, Class N HDPE or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable.

The conduit pipe shall be strong enough to withstand the compression force from heavy trucks or Lorries when it is buried more than 80 cm below the ground level and temperature rise up to 80 degree Celsius.

4.1.3 Accessories

The flexible conduit pipe shall be provided with necessary accessories, such as joints and sealing material etc. The straight joint sleeve shall be made of high density polyethylene black colored and to be so designed as to be screwed on to flexible pipe.

Bell mouth shall be fixed to the end of corrugated pipe to facilitate cable pulling in. The bell mouth shall be so designed as to screw into the pipe. It shall be made of hard density polyethylene and colored black.

Water proof materials for pipes in handhole shall be mounted to an outlet of duct to keep the water tightness. The waterproof materials shall be comprised the components such as sand proof seal, sealing tape, neo seal compound, VUL-CO tape, PVC tape and other necessary materials to complete the specified scope of works.

4.1.4 Technical Requirements for HDPE Pipe

(1) HDPE Pipe 160 mm Diameter

Sl. No.	Item Description	Unit	Requirement
1.	M.F.R. (190 deg C, 5 kg load)	gm/10 min	0.20 to 1.10
2.	Specified base density	kg/mtr ³	940 to 958
3.	Material Grade		PE-80
4.	Pressure rating		PN6 (for HDD method) PN4 (for Open Trench)

(2) HDPE Pipe 125 mm Diameter

Sl. No.	Item Description	Unit	Requirement
1.	M.F.R. (190 deg C, 5 kg load)	Gm/10 min	0.20 to 1.10
2.	Specified base density	Kg/mtr ³	940 to 958
3.	Material Grade		PE-80
4.	Pressure rating		PN6 (for HDD method) PN4 (for Open Trench)



4.1.5 Test

The type test and routine tests shall be carried out for the materials to be supplied according to the above mentioned technical specification in accordance with the governing standard.

Manufacturer shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & type test reports shall be submitted for Employer's approval.

4.2 PLB HDPE PIPE

4.2.1 General

The following paragraphs describe the functional requirements, major technical parameters and Type and Factory Acceptance Testing requirements for PLB High Density Polyethylene (PLB HDPE) Pipe. PLB HDPE pipe shall be suitable for underground fibre optic cable installation by blowing as well as conventional pulling. The PLB HDPE pipe shall be suitable for laying in trenches by directly burying, laying through G.I./RCC Hume pipe, HDPE pipes and laying through trench less digging. The expected service life of HDPE pipe and accessories shall not be less than 50 years. Documentary evidence in support of guaranteed life span shall be submitted by the Contractor during detailed engineering.

The unit rates quoted in the price schedule shall be the composite price of PLB HDPE pipe along with all accessories.

4.2.2 Construction of PLB HDPE Pipe

The PLB HDPE pipe shall have two concentric layers viz. outer layer and inner layer. The outer layer shall be made of HDPE material and the inner layer of solid permanent lubricant. These concentric layers shall be co-extruded and distinctively visible in cross-section under normal lighting conditions and generally conform to IS-9938. The colour of the PLB HDPE pipe shall be finalized during detail engineering. In the finished PLB HDPE pipe, the co-extruded inner layer of solid permanent lubricant shall be continuous and integral part with HDPE outer layer and preferably be white in colour. The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the pipe. The pipe shall be supplied in a continuous length of 1000 (one thousand) meter in coil form, suitable for transportation, installation and handling purposes.

The finished pipe shall be of good workmanship such that the pipe is free from blisters, shrink holes, flaking, chips, scratches, roughness, break and other defects. The pipe shall be smooth, clean and in round shape, without eccentricity. The ends shall be cleanly cut and shall be square with axis of the pipe.

4.2.3 Standards

The HDPE pipe shall conform to the following standard and the technical specifications described in the following sections.

- (a) IS: 4984 / IS: 2530/IS:14151/(part1)/ IS:9938/IS:7328/IS12235(Part-9)/IS:5175
- (b) ASTM D 1693/ ASTM D 638/ ASTM D 648/ ASTM D 790 / ASTM D 1712/ ASTM D 2240/ ASTM D 4565 / ASTM F 2160/ ASTM G 154
- (c) TEC GR: TEC/GR/TX/CDS-008/03/MAR-11 or Latest relevant TEC GR for HDPE pipe for use



as duct for optical fibre cable

4.2.4 Material

The raw material used for the PLB HDPE pipe shall meet the following requirements:

- (a) The anti-oxidant establisthers, color master batch and other additive used shall be physiologically harmless and shall be used only to minimum extent necessary to meet the specification.
- (b) Usage of any additives used separately or together, should not impair the long-term physical and chemical properties of the PLB HDPE pipe.
- (c) Suitable Ultra Violet stabilizers may be used for manufacture of the PLB HDPE pipe to protect against UV degradation when stored in open for a minimum period of 8 months.
- (d) The ash content of the colour master batch shall not be more than 12% when tested as per method detailed below:
- (e) Test Method for ash content: About one gram of the sample under test shall be taken and dried at 105°C for two hours in a platinum or glazed porcelain or silica or quartz crucible. The weight of the sample shall be noted. Subsequently, the sample with the crucible shall be transferred to a muffle furnace maintained at 600±50°C and allowed to remain there for three hours. The ash content may be calculated as a percentage of the weight of the original sample.
- (f) The base HDPE resin used for manufacturing outer layer of pipe shall conform to any grade of IS-7328 or to any equivalent standard meeting the following requirement when tested as per standards referred in this Section below.
 - (i) Density (outer and inner layer): 940 to 958kg/m³ at 27°C. The density of completed PLB HDPE shall not be differ by more than 0.003gms/cc by this value when tested as per IS:2530 or IS:7328.
 - (ii) Melt Flow Rate (MFR): 0.2 to 1.1 g/10 minutes at 190°C & 5 kg load: when tested as per IS:2530. The MFR of the outer layer of the completed PLB HDPE pipe shall not differ by more than 30% of this value.
 - (iii) Tensile Strength at Yield: 20 N/mm² minimum, when tested ss per ASTM D 638, Type-IV specimens
 - (iv) Elongation at break: >600%, when tested as per ASTM D638, Type-IV specimens
 - (v) Flexural Modulus at 1% strain: 690 N/mm² minimum, when tested as per ASTM D 790.
 - (vi) Hardness, Shore-D: Between 60 and 65 units, when tested as per ASTM D 2240
 - (vii) Heat Deflection Temperature at 45 g/mm²: 65°C minimum, when tested as per ASTM D 648.
 - (viii) Environmental Stress Crack resistance, When tested with 10% Igepal, CO 0630 Solution 50°C: 96 hrs., when tested as per ASTM D 1693, No cracks.
 - (ix) Weathering in artificial (UV) light (Specimens shall be as per ASTM D 638 Type-IV) and cut from compression moulded sheet. After exposure for 720 hrs., Tensile strength shall be tested. The variation shall not be greater than 20% compared to tensile strength obtained at above.
 - (x) OIT (in Aluminium Pan): 30 minutes minimum, when tested as per Annexure-I.



- (xi) UV Stabiliser Content: Hindered Amine Light Stabiliser minimum 0.15%, when analysed as per FT-IR method.
- (xii) In the inner layer of PLB HDPE pipe, the friction reducing, polymeric material to be used as the inner layer lubrication material shall be integral with HDPE layer. The lubricant materials shall have no toxic or dermatic hazards for safe handling.

4.2.5 Dimension of pipe

The nominal size of the pipe shall be 40mm and shall meet the following requirements.

- (a) Outside diameter 40 mm + 0.4 mm
- (b) Wall thickness 3.5 mm (+0.2 mm/ -0.00 mm)
- (c) Standard length 1000 meters $\pm$ 100 meter
- (d) Thickness of permanent lubricant, > 0.4 mm
- (e) Maximum outer diameter of FO cable that can be installed by blowing technique 16 ± 0.5 mm or cable dia. whichever is higher

4.2.6 Accessories of PLB HDPE Pipe

The following accessories are required for jointing the pipe and shall be supplied along with the pipe. The manufacturers shall provide complete design details, procedure for method of installation and type of the material used for the accessories. No part of the accessories shall contain metal part and minimum pulling force of the coupler shall be 330kgf. The accessories shall pass the ageing test at $70 \pm 2^\circ\text{C}$ and there shall be no leakage when tested for 168 hours.

- (a) Plastic coupler: The coupler shall be used to join two PLB HDPE pipes. The coupling shall be able to provide a durable airtight and watertight joint between two pipes without deteriorating the strength of the pipes. The strength of coupler shall match the primary strength of the PLB HDPE pipe and threaded coupler is not acceptable. The jointing shall meet the air pressure test of 15 kg/cm² for a minimum period of 2 hours without any leakage.
- (b) End plug: This shall be used for sealing the ends of empty pipe, prior to installation of FO cable and shall be fitted immediately after laying of the PLB HDPE pipe, to prevent entry of any unwanted elements such as dirt, water, moisture, insects/rodents etc.
- (c) Cable sealing plug: This is used to hold the cable and prevent entry of any unwanted elements, as specified above.
- (d) End cap: This cap is made of hard rubber, shall be fitted with both ends of PLB HDPE pipe to prevent the entry of any unwanted elements such as dirt, water, moisture, insects/rodents during transportation and storage.
- (e) Set of installation/maintenance accessories comprising of C-Spanners for tightening plastic coupler (4 nos.), Rotary duct cutter (2 nos.), spare cutting wheel (4 nos. per Rotary Duct cutter), Chamfering tool for giving slight chamfer to the ends of PLB HDPE pipe shall be used during maintenance of the PLB HDPE pipes and these items (1set) shall be supplied along with the pipe.

4.2.7 Workmanship

The pipe shall be free of blisters, shrink holes, break and other defects. The PLB HDPE pipe ends



shall be cut as square as possible to longitudinal aspects. The internal and external PLB HDPE pipe surfaces shall be smooth. The color should be uniform throughout.

4.2.8 Marking

All the pipe shall be clearly marked at intervals of 1 meter with the following data which is not less than 5 mm height. The details of marking on pipe shall be approved by Employer before commencement of manufacturing.

- (a) Employer name with logo
- (b) Manufacturer's name or trademark
- (c) Year of manufacturing
- (d) Type of PLB HDPE pipe and size
- (e) Running length marking

4.2.9 Installation of Underground Fiber Optic Cable System

This section describes the installation procedures and methods including survey, clearances, excavation of trenches and pits, trenchless digging, installation of PLB HDPE pipes, installation of RCC pipes and GI Pipes, marking, backfilling, installation of underground cable, construction of handholes, splicing, termination and site acceptance testing requirements of the underground fibre optic cabling system.

This specification is applicable for underground optical fibre installation work and some miscellaneous works to be executed inside city/town. The quantities indicated in the Price Schedule are indicative only and the final quantities against individual items will be approved by the Employer after detailed survey and depending upon the site condition.

4.2.10 Survey

The choice of route is most important aspect in planning an underground cable system. The correct choice is essential to reduce the cost of laying pipes, keeping the pipes safe from damage and to attain their maximum utilization when they have been laid.

The survey shall be conducted for underground fibre optic cable routes as described below to finalise the route and paths for the underground fibre optic cable. For underground fibre optic cable links, location of customers such as: Telecom service providers (NTC/NCELL, other basic operator, Cellular, Pager, ISPs etc), Major business centres, Bulk data users (Corporate Houses, universities, colleges etc) shall be identified by the Contractor and submitted to

Employer by suitably marking the locations on a city map of proper scale. In certain cases, there will be routes where the Employer has finalized the route for the installation of PLB HDPE pipe vis-à-vis the underground OFC, or PLB HDPE pipe is already installed by Employer or another agency. In such cases, the Employer shall provide the details of the finalised route or existing PLB HDPE pipes routes to the extent possible. However, to carry out the fibre optic cable installation, the Contractor shall carry out the required survey of the routes.

(1) Identification of Underground Fiber Optic Route

The Contractor shall propose preferably two most suitable routes (unless availability of a single route is obvious) for each link keeping in view the following broad criteria:



- (a) The route shall be as straight and as short as possible
- (b) The route shall have minimum obstacles in order to minimise reinstatement cost.
- (c) Clearances required from other authorities/bodies are minimum and that the clearances can be obtained expeditiously.
- (d) Wet or unstable ground shall be avoided to the extent possible.
- (e) The route for the pipes shall be away from the carriage-way of the road to the extent possible.
- (f) The route shall be suitable for placing handholes wherever required.
- (g) Future expansion of roads shall be taken into consideration.
- (h) Road, rail, river, nallah crossings shall be minimum.
- (i) Underground fibre optic cable route shall be so chosen that it would be possible maintain sufficient distance from existing underground cables and to do excavation and backfilling along the route without disturbing the existing cables laid by other operators/utilities during installation of PLB HDPE pipe or future maintenance, to the extent possible subjected to ROW clearance.

(2) Survey Report

The Contractor shall submit the survey report with the most suitable two alternate routes for all the fibre optic links along with details described above. The Employer shall choose one of the two alternatives. On finalisation the Contractor shall carry out detail survey for the selected routes and submit the final survey report for approval before implementation. The final survey report shall include at least the following:

- (a) A drawing of the proposed route indicating all details of the route including name of the road, GIS co-ordinates at every 25 mtrs, relevant details of soil strata, bridges, culverts, causeways, rail over/under bridges, defence area, underground gas / oil / water pipe line, power and communication cables routes, other important landmarks etc.
- (b) The distance of the fibre optic cable route from the centre of the road/rail/river//bridge/culvert etc. shall be indicated on the route maps as well as documented in tables.
- (c) Sections of the links where Horizontal Direction drilling, Moiling and Manual auguring may be required.
- (d) Sections where GI or RCC Hume pipe may be required.
- (e) Location and number of permanent and temporary handholes.
- (f) Location of all turns, bends and major landmarks.
- (g) Type, quantity and location of all the joint boxes. Care must be taken to minimise the number of splicing and joint boxes.
- (h) Section lengths of the underground fibre optic cable, total length of each link and drum scheduling for all the link.



- (i) List of authorities from which clearance shall be required to be obtained for each relevant section.

The final survey report shall have to be approved by the Employer and requisite clearances (as indicated below in this section) need to be obtained before the cable installation work is commenced.

For the routes where the Employer has finalised the route for installation of PLB HDPE pipe vis-à-vis the underground OFC or where PLB HDPE pipe is already installed by the Employer/Owner or other agency, the Contractor will survey the route to facilitate installation of optical fibre cable, and submit the final survey report as per above description.

The scope of survey shall also include the route and tentative Bill of Materials (pipes, couplers, handholes, G.I. pipes, RCC pipes, Joint box, conduits, bends, trays, warning bricks, Warning tape etc. and any other items required for successful implementation of the links) for the interconnection of optical fibre cable from the nearest handhole to the fibre termination box (FODP/FMS). It may be noted that routing of optical fibre cable inside the building may require installation on the walls and floors using suitable pipes, conduits, bends, trays etc and minor civil works (e.g. making holes on the walls, cutting grooves on walls/floor and making good etc.).

4.2.11 Installation of PLB HDPE Pipe

PLB HDPE pipe shall be laid at bottom of the trench after making the surface smooth and stone free sand bedding or inside HDPE pipe.

After laying the pipe (where it is not laid inside HDPE pipe) additional sieved sand shall be added to increase the height of the sand layer to a total of 200 mm hence positioning the PLB HDPE pipe in the middle of the layer. Other important steps are described as under:

- (a) PLB HDPE Pipe shall be laid in a flat bottom trench free from stones, sharp edged debris.
- (b) The Pipe shall be placed in trenches as straight as possible. Minimum bending radius of pipe and fibre optic cable shall always to be taken into account.
- (c) The ends of pipes shall always be closed with end plugs to avoid ingress of mud, water or dust i.e. all pipe opening shall be sealed to avoid entry of foreign material.
- (d) The pipes shall be joined tightly & properly through plastic couplers and the joint shall be smooth and free from steps. The joints shall be made properly so that it passes the duct integrity test specified in this section. All joints shall be assembled with proper tools only.
- (e) Coupler shall not be placed along the bend portion of the pipe
- (f) Cable sealing plugs shall be provided at all handhole locations and at locations cable is coming out of the pipe and empty pipe ends i.e. all pipe openings shall be sealed to avoid entry of foreign objects.
- (g) PLB HDPE pipes shall be installed in a manner that fibre optic cable can be pulled, blown, de-blown without damaging the fibre optic cable due to stresses.

The Contractor shall inspect all joints before carrying out the backfilling along with representative of Owner/Employer. Joints shall be visually inspected and checked for tightness.

Unit rate for installation of PLB HDPE pipes shall interalia include all related works/activities including installation of all accessories/hardware described in this section. Accordingly, the unit rate quoted shall include all wastages, working length etc. and all other items/works required for PLB



HDPE pipe installation. The Owner/Employer shall not entertain any claims or payment towards installation of hardware/accessories, installation of additional lengths of PLB HDPE pipe required to be taken for working lengths and wastages etc.

Handhole are marked at every 200m or at bends or turns for installing UGFO cable through HDPE duct. HDPE end caps used for sealing the PLB HDPE Ducts, to avoid entry of rodents/mud etc.

4.2.12 Acceptance Testing of PLB HDPE Pipes

After installation of PLB HDPE pipes, the PLB HDPE pipes shall be checked over the whole lengths in order to ensure integrity and its suitability during fibre optic cable blowing/pulling. The installed PLB HDPE pipes shall be checked as per the requirements specified in this section.

In case of any problem, the Contractor shall rectify the same and re-digging and/or re-installing of PLB HDPE pipes shall be carried out by the Contractor at no additional cost to the Employer. After acceptance test, both ends of each PLB HDPE pipe shall be again properly sealed.

The Contractor shall submit the exact method/procedure for the above tests for Employer's approval.

4.2.13 Type Testing

The PLB HDPE pipes & accessories offered to be supplied should have been type tested as per requirement specified in TEC/GR/TX/CDS-008/03 MAR-11 with latest revisions or equivalent standard. The Contractor shall enclose the previous type test report according to relevant international standard for the proposed PLB HDPE duct meeting the specified requirement.

4.2.14 Factory Acceptance Test

The following tests shall be carried out during Factory Acceptance Test.

Se. No.	Name of the Test
1.	Visual Inspection
2.	Dimension Check
3.	Hydraulic Characteristics
4.	Reversion Test
5.	Tensile Strength and Elongation Test
6.	Environmental Stress Crack Test
7.	Impact Strength Test
8.	Crush Resistance
9.	Mandrel Test
10.	Ovality Test
11.	Coil Set Test
12.	Internal Co-efficient of Friction
13.	Ash Content
14.	Colour Fading
15.	Optical Fiber Cable Blowing Test
16.	Air Pressure Test on Plastic Coupler
17.	Aging Test on Accessories

The air pressure test of plastic coupler shall be carried out for at least two joints made together with the offered PLB HDPE pipe. Each of the offered PLB HDPE pipe reels shall be weighed which should not be less than as specified in the Guaranteed Technical Particular (GTP).

4.2.15 Site Acceptance Test

For PLB HDPE pipes, duct integrity tests shall be carried out as described below. The Duct cleaning

(Sponge test) test shall be carried out on all the ducts before blowing/pulling of the cable between two consecutive handholes on the PLB HDPE pipes.

(a) Duct Cleaning (Sponge Test)

Compressed air should be blown through the PLB HDPE pipe in order to remove dirt and water, if any, with the help of suitable Air Compressor. A short blast of air about 2-3 Bar shall be blown through the PLB HDPE pipe for about 2 minutes. Sponge shall be blown through the duct to thoroughly clean the duct from inside.

(b) Crush and Deformity Test

Place a shuttle of length <15cm and O.D. 80% of the inner diameter of the offered PLB HDPE pipe. Connect the compressor pipe with a suitable flexible wire grip at the other end to catch the shuttle and start blowing operation to the pipe and check if shuttle reaches at the other end. If shuttle gets stuck the Contractor shall adopt suitable arrangement at site to locate the deformity/damage in the HDPE pipe, repair the pipe and ensure end-to-end continuity of the duct in sound condition

4.3 PVC PIPE FOR SERVICE CABLE

4.3.1 General

The following paragraphs describe the functional requirements, major technical parameters and Type and Factory Acceptance Testing requirements for PVC Pipe. PVC pipe shall be suitable for underground LT service cable installation. The PVC pipe shall be suitable for laying in trenches by directly burying and laying through trench less digging. The expected service life of PVC pipe and accessories shall not be less than 30 years. Documentary evidence in support of guaranteed life span shall be submitted by the Contractor during detailed engineering.

The unit rates quoted in the price schedule shall be the composite price of PVC pipe along with all accessories.

4.3.2 Construction of PVC Pipe

PVC pipe shall be maintenance-free performance in underground, encased and exposed applications in accordance with the National Electrical Code. PVC Pipes shall be

- Corrosion Resistant
- Non-Magnetic and Non-galvanic
- Self-Extinguishing
- Impact Resistant

4.3.3 Standards

rigid PVC pipes shall be used with 90° C conductors, in accordance with the National Electrical Code. They are manufactured in accordance with NEMA TC2.

PVC fittings are manufactured in accordance with NEMA TC3.

4.3.4 Specification

All wiring shall be installed in rigid PVC pipes and secured by means of proper fittings. Exposed



pipes shall be securely attached and supported by means of straps. The straps shall be installed at the recommended spacing as specified in the National Electrical Code (NEC). The straps must allow for linear expansion and contraction of the pipes due to temperature change. If the variance in temperature exceeds 15°C expansion joints shall be installed according to the manufacturer's recommendations.

If rigid PVC pipes are embedded in concrete or direct buried, Schedule-80 PVC Rigid Pipes shall be used and support straps are not required

4.4 HANDHOLES

Handholes shall be provided at around 200m and at proposed future joint location to house Joint Box and Optical Fibre cable service loops. The location for Joint boxes shall be decided during survey and detailed engineering. At RMU and GO switch locations, joint box Handhole are proposed. For the other Handhole where joint box is not proposed fibre loop to be provided.

There can be three types of construction of handholes depending upon the location of the handhole. Each type of construction of handhole can be of two sizes (heights) depending upon the utility. Where the handholes are placed on the footpath or where heavy vehicular movement is not expected, handhole with brick masonry wall (wall thickness min. 225mm and inside dimension 1000mmx1000mm square, inside wall 12mm cement plaster with 1:4 mix) can be constructed. However, in case the handhole is required to be constructed at the middle of the road or where heavy vehicular movement is expected, the handhole shall necessarily be of RCC construction. Such handhole shall be precast RCC Cylindrical pipe (spun concrete) with minimum wall thickness of 80mm and shall include $\Phi 8$ mm or more steel reinforcement. The base of handhole in all types shall be minimum 80mm thick PCC and minimum internal diameter shall be 1000 mm. In case the base is constructed as integral part of the precast RCC cylinder, the base shall also be RCC. Height of the handhole, where joint boxes are to be kept, shall be of 1100 mm height. Handhole for keeping service loops of OFC shall be of minimum 400mm height. The cover shall be precast RCC, minimum 50mm thick. However, for easy handling purpose, the cover is to be constructed with suitable arrangement for lifting. The top of handhole should be flushed with the ground level. Handholes type approved by the Employer shall only be acceptable. Handhole shall be designed as per the typical drawing enclosed at Annexure-I. The handhole shall have two holes in each four perpendicular directions for PLB HDPE/HDPE pipe entries and exits. Fixtures for placing cable and spliced Joint Box inside the handhole shall be provisioned. The joint box shall be mounted vertically on the wall of the handhole. The Contractor shall carry out the required excavation and backfilling for the construction of the handhole. All PLB HDPE pipe entries, cable entries and holes shall be properly sealed.

The Contractor may propose double walled "Annual ring-shaped conical handholes" meeting all the requirements of the handhole specified above. The assembly of conical handhole shall be made by using pre-cast steel (rod or wire-mesh) reinforced Concrete elements, which consists of annular rings different height and diameter (within permissible diameter range of conventional handhole as specified above) placed over each other. Handholes type approved by the Employer shall only be acceptable. For installation of PLB HDPE pipe or trenchless digging or blowing of OFC, at times there might be requirement of providing temporary handhole or hand holes. No separate payment shall be admissible for such handholes or handholes and shall be deemed to be inclusive in the overall scope of work by the Contractor.

If required, as per the advice of the Employer, handholes shall also be installed along the existing installed PLB HDPE pipe routes to house joint boxes and cable service loops. Due care is to be



taken so that the existing PLB HDPE pipe and OFC does not get damaged while placement of new handhole.

Unit rate for the handholes shall inter alia include all related works/activities including RCC cylindrical pipe, Brick masonry work, PCC base, precast cover, excavation, backfilling, supply, transportation and installation of all material & accessories required for construction of handhole as per specification. Provisional quantity for all types of handholes (viz. handhole for service loops and for joint box, RCC and Brick Masonry Construction) handholes has been identified in the appendices, payment shall be made based on actual quantities executed.

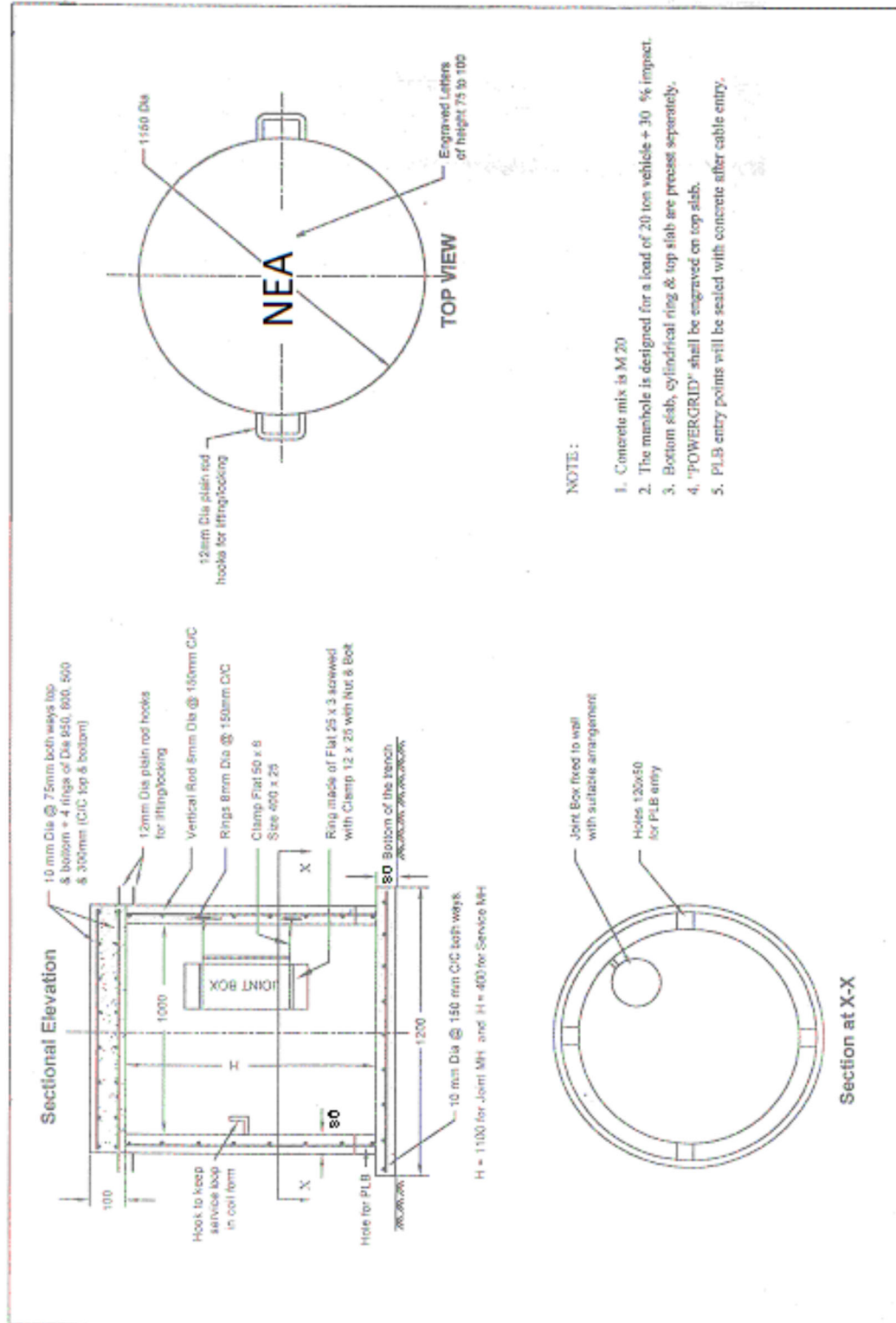
4.4.1 Site Acceptance Test

Site Acceptance Tests for Handhole shall be done as per the direction of Employer.



4.5 CABLE TROUGH (TRENCH)

In the premises of substation, underground cable can be installed in a cable trough. The installation work of the cable trough is considered a part of the civil work for Substation, so the installation cost shall be included in the Price Schedule of Substation Work.



The cable trough and the cover shall be constructed using RCC of M20 grade.

The cable trough shall be designed for the following load.

- Dead load of 155 kg/m of cable support plus 75 kg on one tier at the end.
- Triangular earth pressure plus uniform surcharge pressure of 2 tons sq.meter.
- Cable trench covers shall be designed for (1) self-weight of top slab plus concentrated of 200 kg at center of span on each panel and a surcharge load of 2 tons per sq.meter.

The cable trough shall be capable of installing at least 20 underground cables.

Trenches shall be drained. Necessary sumps be constructed and sump pumps shall be supplied. Cable trenches shall not be used as storm water drains.

The top of trenches shall be kept at least 250 mm above the finished ground level. The top of cable trench shall be such that the surface rain water does not enter the trench.

All metal parts inside the trench shall be connected to the earthing system.

A suitable clear gap shall be maintained between trench walls and foundations.

A clear (vertical) space of at least 300 mm shall be available for each tier in the cable trench. From the trench bed to the lowest tier, a minimum clearance of 200 mm shall be available for one tier trench and 300 mm for trenches having more than one tier. The spacing between stands shall be 400mm.

Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

Cable tray supports (all galvanized structures) shall be designed and constructed to be a single complete fabrication or assembly such that every layer of the horizontal cable tray supports is fixed, either bolted or welded, to a vertical steel support that is embedded in the concrete wall of the cable trough. It shall not be permitted to embed a horizontal support beam directly into the wall of the trough in order to use the concrete wall as a means of load bearing.

Concrete troughs shall be provided with concrete covers of suitable load bearing strength. Where the cable troughs are run across or within 3 m of substation roads, the trough covers shall be capable of bearing an accidental wheel load of 20 kN.

Beneath the concrete, a layer of stones and sand will be laid to ensure the ground stability.

4.6 GI PIPE

The GI pipe of nominal bore of minimum 150 mm shall be laid wherever road crossings, bridge crossings, railway crossings are encountered on the route as well as on wall/floor crossings in a building. PLB HDPE pipe shall be inserted into GI pipe. Whenever it is not possible to install the FO cable underground due to non availability of the right of way or any other unavoidable reasons, the HDPE ducts along with FO cable shall be installed in GI pipe on the existing rock/concrete/brick wall/surface with suitable fixing arrangement and concreting, if necessary, with specific approval of the Employer in case-by-case basis. The GI pipe shall conform to at least medium class and conform to IS: 1239 (Part –I). In regard to bridge and culvert crossing, GI pipe may be installed by concreting the GI pipe along the bridge or by using supporting brackets or by laying underneath the existing footpath etc. The PLB HDPE pipes shall be installed through this GI pipe. Wherever underground fibre optic cable is required to be spliced to overhead fibre optic cable using the outdoor FODPs/Joint Boxes installed on towers, GI pipes shall be used to protect the portion of the cable/duct up to a height of about 6 to 10 meters and shall be extended in the ground up to suitable depth of the trench so that minimum bending radius of the cable is maintained. The GI pipe shall



be properly clamped/ fixed on the tower leg. The Contractor shall supply and install all necessary accessories as part of the installation work.

The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Employer:

- (a) The GI pipe shall be extended at least 5 meters on each side of crossing subject to availability of space and approval of the Employer.
- (b) Two GI pipes shall be joined using proper tools, sockets and accessories etc.
- (c) Proper arrangements shall be made to seal the ends of GI pipe after installation of PLB HDPE pipes.
- (d) Minimum bending radius of optical fibre cable shall always be taken into consideration.
- (e) 1:2:4 concrete shall be used for encasing of the GI pipe, wherever required.
- (f) The floor of the trench shall be levelled by laying at least 50 mm of soft soil or sieved sand before installing the GI pipe.
- (g) The GI pipes shall be supplied in standard lengths of 6m or as approved by Employer.
- (h) The GI pipe shall be sealed at both ends.
- (i) The GI pipe of suitable length shall be provided at road crossings, bridge crossings, railway crossings encountered on the route as well as on wall/floor crossings in a building and also for protection of fibre optic cable at tower/pole mounted joint boxes.

The quoted unit rate for the supply of GI pipe shall inter alia include all required accessories (sockets, joints, brackets, clamps etc) and material (cement, sand, chips etc). The quoted unit rate for the installation of GI pipe shall inter alia include all related works/activities including installation of hardware and accessories (sockets, joints, brackets, clamps etc), fixing arrangement and concreting required for GI Pipe installation at road crossings, bridge crossing, railway crossing encountered on the route as well as on wall/floor crossings in a building. PLB HDPE Pipe shall be laid in the GI pipe, accordingly the quoted unit price shall take into account working lengths and wastages. The Owner/Employer shall not entertain any claims or payments towards installation hardware, accessories, concreting, cementing, working length and wastage etc.

4.7 TRUSS BRIDGE FOR CANAL CROSSING

At the river crossing, in case that underground cable cannot be installed using GI pipe and pipe supports along the bridge, truss bridge shall be constructed. GI pipe shall be installed on the bridge and then underground cable shall be installed in the GI pipe.

The general features for the truss bridge shall be following.

- The width and the height shall be 50 cm.
- The river span shall be 10 m.
- The Material shall be Galvanised Steel.

The steel needs to be protected as effectively as possible against corrosion. The most effective method is galvanising all components, but this treatment is unlikely to be available.

The following treatment is therefore recommended before bolting together the panels:



- On completion of welding the panels clean up all welds and weld splatter by grinding and wire brushing
- Thoroughly wire brush all surfaces to remove scale and any rust
- Paint all surfaces with a good quality, oil-based, anti-corrosion paint by spraying or brushing. This should comprise 3 coats – a primer/undercoat followed by 2 top-coats. Careful attention should be given to getting into all corners, inside drilled holes and sealing joints such as along the top longitudinal
- A particular problem is to protect the inner surfaces between the channels of the bottom longitudinal of the end and side panels where there is only a 6mm gap. This can be achieved most successfully by spraying the paint. If this is not available a means of spreading the paint with an improvised brush having sufficiently long bristles or a suitable cloth or scraper blade that can be passed through the gap and pulled along the length of the gap should be used.

The decking is not required.

Factors to be considered in the design and construction of the abutments include:

- The soil characteristics and allowable bearing pressure to determine the minimum contact area or footing area of the abutment on the soil
- The stability of the soil – Appendix A defined a maximum slope of the bank at the location of the abutments of 60° for stable rock down to 35° or less for soft soil and gravel. In the latter case piles may be needed and anchors to stabilise the abutment
- The flood level in relation to the abutments and whether protective measures are needed to counter erosion of the bank around the abutments
- The bearing area of the abutment where the footbridge is supported, especially for timber footbridges
- The arrangements for fixing the footbridge in position so that it is not easily washed away.

The long-term sustainability of any bridge is largely dependent on the strength and stability of its abutments. The proper selection, design and construction of abutments are therefore critical to the life of the bridge.

The forms of construction include:

- Existing rocks: if suitably large and stable rocks are available on the banks of the stream/river they can be used as abutments. Masonry or concrete can be used to build up an even bearing seat for the footbridge.
- Masonry: if suitably large stones are locally available they can be bound together with mortar to produce a relatively low-cost and long-life abutment.
- Mass concrete: this is plain concrete without steel reinforcement. A larger section and therefore more concrete is needed than for reinforced concrete.
- Reinforced concrete: this involves a more complex construction and the need for experienced workers

(1) Abutment on Existing Rocks

It will probably be necessary to build on top of the rock to raise the level of the bearing surface and/or provide a level bearing seat. This may be done with masonry and/or concrete depending on how much the seat has to be raised.

It is important to achieve a good key between the added material and the existing rock. The surface of the rock should be roughened up with a hammer and chisel or sledgehammer and possibly holes made to insert pieces of reinforcing bar to be embedded in the concrete/masonry cap.



(2) Concrete and Masonry Abutments

These will be considerably more durable and longer lasting than timber abutments but will also be more costly. They require the excavation of footings and the construction of formwork to produce the shape of the abutment. They will therefore need workers, including masons and carpenters, with some experience in this type of work.

4.8 CABLE RACEWAY

The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

- (a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.
- (c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

4.9 AS BUILT DRAWINGS/DETAILS

The Contractor shall submit the as built drawings for the whole route indicating the route, depth of digging and handhole locations for easy maintenance of the installed system.

- (1) List of Drawings/documents required to be submitted for Employer's approval

The Contractor shall ensure that the required drawings and documents are submitted well in time to avoid any delay in approval and project execution. The following minimum drawings and documents are required to be submitted by the Contractor for approval of the Employer:

- (a) Final Route Survey Report including handhole locations
- (b) The method/procedures and the equipment/machines to be used for different types of trenchless digging technique
- (c) Bill of quantities for various items as per contract
- (d) SAT Reports
- (e) As built drawings

4.9.1 Documentation

Apart from survey reports as mentioned above, the Contractor will submit the following documents after completion of the job and acceptance by the Employer:

- (a) As built drawing of the route indicating the distance from road centre, location of other utilities, link BoQ, OFC loop length, name of the road, sections and positions of PLB HDPE pipes, couplers, warning bricks/stone, handholes, G.I. pipes, RCC pipes, joint box, conduits, bends,



trays, optical fibre cable loop lengths in handholes etc.

- (b) Depth of PLB HDPE pipe in various sections of the route executed through open trenching.
- (c) Sections of trenching digging executed through various methods.
- (d) Splicing/termination details of each joint box/FODP. Attenuation and splicing loss measurement data shall be submitted for each fibre.
- (e) Specific deviation with reference to the installation and supply items, if any, from the technical specification. If there is no deviation, either explicit or implicit, the Contractor will provide a certification to this effect.
- (f) Without submission of the above documentations, the Site Acceptance Testing of various items as described above will be deemed to be incomplete.

4.10 MISCELLANEOUS WORKS

In order to provide end-to-end connectivity, it may be required to execute some miscellaneous jobs as detailed below.

- (1) Routing of Cables inside buildings

In order to route the OFC (Optical Fibre Cable) from the underground trench to the FODPs it may be necessary to install the cable on walls inside PLB HDPE pipe over the existing cable tray/raceways inside the building.

- (2) Installation of PLB HDPE pipe on wall

The PLB HDPE pipe may be required to be installed on the wall using steel or G.I clamps. The Contractor will provide the required clamps and other consumables sufficient for such installation. The Contractor will take care of aesthetics while installation. The OFC will be pulled through the PLB HDPE pipe with due care as described in relevant Para of this specification.

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CHAPTER 5:

RING MAIN UNIT (RMU)



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CHAPTER 5: Ring Main Unit (RMU)

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
5.1	General Requirements.....	1
5.1.1	Scope.....	1
5.1.2	Standards and Reference Documents	1
5.2	Description	2
5.2.1	Application	2
5.2.2	Insulating and Switching Mediums.....	2
5.2.3	Design Criteria	4
5.2.4	General Technical Requirements	5
5.2.5	Busbars.....	6
5.2.6	Load Break Switches (Isolators)	6
5.2.7	Earthing of isolators and distribution transformer breakers (Earth Switch)	6
5.2.8	Circuit Breaker (Vacuum).....	7
5.2.9	Bushings	8
5.2.10	Cable Boxes	8
5.2.11	Voltage Indicator Lamps and phase comparators	8
5.2.12	Extensible	8
5.2.13	Fault Passage Indicators / Earth Fault Indicators (FPI/EFI).....	8
5.2.14	Auxiliary Transformer	10
5.2.15	Power Supply.....	10
5.2.16	Battery	11
5.2.17	Battery Charger	11
5.2.18	Motorization	12
5.2.19	Metering Arrangements.....	12
5.2.20	SCADA Connectivity	12
5.3	Testing and Certification	13
5.3.1	Type Tests.....	13
5.3.2	Routine Tests	14
5.4	Documentation.....	14
5.5	List of Drawings and Documents	14
5.6	Name Plate	15



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5.1 GENERAL REQUIREMENTS

5.1.1 Scope

This specification for SF6 insulated Ring Main Units (RMU) covers design, manufacture, shop testing, inspection, packing, and delivery to site. The units shall be of 11kV metal enclosed, panel type, extensible and suitable for indoor and outdoor applications. The units shall be fully type tested according to IEC 62271-200 standards.

The RMUs should be complete with all components necessary for effective operation along with all required associated equipment. All required components shall be deemed to be within the scope of supply.

The design of the switchgear should be exclusive and specific responsibility of supplier and should comply with current good engineering practice, the relevant codes and recommendations and the project specific requirements.

The RMU's should be fixed type SF6, insulated Vacuum Circuit Breakers, for transformer protection shall be equipped with an O/C & E/F relay. The RMU's shall effectively be maintenance free.

5.1.2 Standards and Reference Documents

The standards to be applied for design, manufacture and tests shall include the following IEC Recommendations and/or equivalent internationally recognized standards. The specification shall be suitable for satisfactory operation under the tropical conditions.

IEC 60694	:	Common specifications for high-voltage switchgear and control gear standards
IEC 60298	:	AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 72 kV and the IEC Codes herein referred.
IEC 60129	:	Alternating current Disconnecter (isolators) and earthing switches IEC 60529: Classification of degrees of protection provided by enclosures
IEC 60529	:	Classification of degrees of protection provided by enclosures
IEC 60265	:	High-voltage switches -Part 1: Switches for rated voltages above 1kV and less than 52 kV
IEC 60056	:	Circuit breakers
IEC 60420	:	High-voltage alternating current switch-fuse combinations
IEC 60185	:	Current transformers
IEC 60186	:	Voltage transformers
IEC 60255	:	Electrical relays

Any other codes recognized in the country of origin of equipment might be considered provided that they fully comply with IEC standards.

The design of the switchgear should be based on safety to personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment, interchangeability of equipment and ready addition of future loads.



5.2 DESCRIPTION

5.2.1 Application

RMUs shall be used for indoor and outdoor applications. The Ring Main Unit shall be installed at 11kV junction points and sections such as to isolate faulty section. The RMUs shall be both extensible and non-extensible according to the procurement as specified in the Price Schedule. The RMU shall have front access with anti-theft hinge arrangement with minimum of 3 hinges. The RMU shall be fitted with four numbers of lifting lugs or manufacturer to provide standard operating procedure for lifting of RMUs.

(1) Indoor, if specified in the Price Schedule:

- (a) Extensible or as per the Price Schedule
- (b) The Equipment shall also be suitable for installation in a concrete building structure in substations;
- (c) The Equipment shall require a mounting base;
- (d) Metering unit (optional) can also be incorporated into the switchgear;
- (e) Interfaces to SCADA/DMS system shall be provided.
- (f) Modular design, panel type with front cable access.
- (g) RMU's SF6 compartments must be made of robotically welded stainless steel.

(2) Outdoor:

- (a) The Equipment shall be suitable for mounting on foundation
- (b) The Equipment shall require a mounting base;
- (c) Interfaces to SCADA/DMS system shall be provided.
- (d) Hermetically sealed metallic Epoxy / Stainless steel enclosure for Outdoor RMU application. The manufacturers shall confirm the normal current ratings mentioned in Guaranteed Technical Particular (GTP) at 40 degrees ambient without de-rating.
- (e) Enclosure with IP54 standard protection.
- (f) Offered RMUs must be extensible or as per the Price Schedule.
- (g) Cable boxes shall be on Front / side / rear sides.
- (h) Shall consist of Load Break isolators and circuit breaker as per the Price Schedule.
- (i) RMU enclosure must be shielded against solar irradiation and tested for ambient of 40 degrees C. The manufacturers shall confirm the normal current ratings mentioned in GTP at 40 deg. Ambient without de-rating.
- (j) Metering unit (optional) can also be incorporated into the switchgear;

5.2.2 Insulating and Switching Mediums

Breaker Switch units shall be of vacuum interrupter type however complete tank should be filled



with SF6 gas as an insulating medium.

(1) Vacuum Interrupters

Vacuum Interrupters may be used for Circuit Breakers and switch- disconnectors. The contacts for vacuum interrupters shall be positively driven in both the OPEN and CLOSE directions and in no way be dependent on the interrupter vacuum. The vacuum bottles shall be sealed for life.

(2) SF6 Gas Enclosure

The SF6 gas used shall comply with the requirements in accordance with IEC376 and shall be suitable in all respects for use in RMUs under the stipulated service conditions.

It is preferable to fit an absorption material in the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption.

The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go, no-go indication.

The SF6 shall be tested for purity, dew point air hydrolysable fluorides and water content as per IEC 376,376A and 376B and test certificate shall be furnished to the owner indicating all the tests as per IEC 376 for each Lot of SF6 Gas as IEC 62271-200. Equipment that requires the periodic filling of SF6 gas shall not be considered.

A stainless steel label shall be fixed to the RMU stating the total mass and volume of SF6 gas present in the RMU at a specified date. The Vendor shall state in the GTP, during detail engineering, the nominal SF6 gas filling pressure and nominal fill temperature.

(3) SF6 Gas Annual Loss

The annual loss rate of SF6 gas shall not exceed 0.1% of the total mass. The vendor shall substantiate with document/calculation that pressure of the SF6 gas shall be above the operating limit throughout the lifetime of the equipment. The switchgear shall not remain energized with load connected if there is no SF6 gas inside the tank.

(4) SF6 Gas Pressure Gauge/Non-return Valve & Low Gas Switch

A robust SF6 gauge(s) shall be provided for visual indication of SF6 gas pressure inside the switchgear chamber. The SF6 gauge shall be readily visible from the front of the unit without the necessity to remove any covers and be clearly marked to indicate the normal gas pressure by a green area on the gauge face and the low gas pressure by a red area on the gauge face. The gauge shall incorporate temperature compensation or have a gauge face that corresponds to different temperature ranges.

The SF6 gauge shall be fitted to a non-return valve that prevents loss of SF6 gas. The non-return valve shall facilitate the following:

The switchgear and bus-bar housing containing SF6 gas shall be sealed for life except one common



access point for the SF6 gas gauge sensor via the SF6 gas non-return valve.

A low pressure SF6 gas switch shall be provided in manometer for low pressure alarm. The low pressure switch is to be set to operate at pressure which will indicate loss of SF6 within switchgear and will not generate false alarms as the SF6 gas pressure drops due to the ambient temperature drop or change.

5.2.3 Design Criteria

(1) Service Condition

The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated in this Chapter. Installation shall be in normal outdoor conditions in accordance with IEC 60694.

(2) General structural and mechanical construction

The offered RMUs should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is made of a cubicle sealed-for life with SF6 and contains all high voltage components sealed off from the environment.

The overall design of the indoor switchgear should be such that front access only is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

The units should be constructed from 2 mm thick CRCA sheets. The design of the units should be such that no permanent or harmful distortion occurs either when being lifted by eyebolts or when moved into position by rollers. However, if vendor has standardized the thickness of enclosure other than above mentioned and it meets the performance requirements and the design has been established through type test, the same shall be accepted.

The unit shall also have space to house SDH/MPLS equipment (for communication) and FMS (Fiber management System). The typical space requirement for SDH/MPLS equipment shall be 1U and for FMS shall be in different sizes like 1U, 2U, 3U, 4U for different RMUs. Requirement of FMS size shall be finalized during detailed engineering as per site requirement, However SDH/MPLS size will remain same for all the RMU panels.

For outdoor RMUs a weather proofing process shall be carried out. Sheet metal must be grit Blazed / thermally sprayed and polyurethane painted with about 70 micron thicknesses, to achieve outdoor worthiness and corrosion proofness.

The cubicle should be having a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases are allowed to be exhausted out at the bottom / top / rear of the cubicle. A controlled direction of flow of the hot gas should be achieved. The cubical shall be tested for AFLR for 25 kA for 3 sec.

The switchgear should have the minimum degree of protection (in accordance with IEC 60529)



- IP 67 for the tank with high voltage components
- IP 2X for the front covers of the mechanism
- IP 3X for the cable connection covers
- IP 54 for the outdoor enclosure

5.2.4 General Technical Requirements

Fixed type Vacuum circuit breakers. It should be maintenance free, having stainless steel robotically welded enclosure for INDOOR RMU & hermetically sealed metallized Stainless steel enclosure for OUTDOOR RMU application.

The rating of enclosure shall be suitable for operation on three phase, three wire, 11 kV, 50 cycles, A.C. System with short-time current rating of 25 kA for 3 seconds for 11kV.

Each switchboard shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics.

The Switchgear and Switchboards shall be designed such that the position of the different devices is visible to the operator on the front of the Switchboard and operations are visible.

In accordance with the standards in effect, the switchboards shall be designed so as to prevent access to all live parts during operation without the use of tools.

Each RMU shall include its own power supply unit (including auxiliary power transformer, maintenance free batteries, and battery charger), which shall provide a stable power source for the RMU. The RMU will also supply 24VDC 500VA for FRTU and -48V DC Power for Communication Equipment.

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. The appropriate converter for the same shall be provided.

Each RMU shall be equipped with main-line load break switches and a fault passage indicator (FPI). Furthermore, to protect each of its lateral / transformer feeders, it shall be equipped with a corresponding set of circuit breakers and self- powered numerical relays. The RMU shall include potential-free contacts and control contacts so as to connect to SCADA/DMS via FRTUs, so as to:

- (a) Monitor and control the open/closed status of the RMU circuit breakers and load break switches.
- (b) Monitor the local/remote position of RMU motorized (in case of failure of motor) manually-operated switches that can be used to enable and disable remote monitoring.
- (c) Monitor the health of the power supply, which will include battery failure and low voltage



indications.

- (d) Monitor the open/closed status of RMU earthing switches.
- (e) Monitor the open/closed status of RMU enclosure doors in case of Hinge doors.
- (f) Monitor for low SF6 gas pressure indication.
- (g) Monitor for circuit breaker relay operations.
- (h) Monitor for indication of main-circuit fault detected by the RMU's FPI.
- (i) Necessary current sensors / transformers for protection and metering (wherever required).
- (j) All necessary dry (potential-free) contacts for indications relevant to RMU monitoring status and control.
- (k) A PT Panel including auxiliary power transformer for measurement of system voltage and for charging the batteries
- (l) Battery and battery charger, to provide stable as per motor rating, 24V DC power for the RMU's motor.

5.2.5 Busbars

The three numbers of continuous Busbars made up of EC grade copper of rating current 630A shall be provided. The Short time rating current shall be 25 kA for 3 seconds for 11 kV. The Busbar connections shall Anti- oxide greased. The bus bar should be integrated in the cubicle. Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

5.2.6 Load Break Switches (Isolators)

The Load Break Isolators for Incoming and Outgoing supply must be provided, and the load break isolators are fully insulated by SF6 gas. The operating mechanism shall be spring assisted mechanism with operating handle for ON / OFF. Earth positions with arrangement for padlocking in each position. Also, it shall have the provision of independent manual operations with mechanically operated indicator.

The earth switch shall be naturally interlocked to prevent the main and earth switch being switched 'ON' at the same time. The operation of the main LBS and earth switch to be made by lever/handle/operating rod with necessary interlocks as per IEC standards. The load break isolators should have the facility for future remote operation. Each load break switch shall be of the triple pole, gang operated and with integral earthing arrangement.

The rated current of Isolator shall be 630 Amps Continuous at 40 degree C Ambient temperatures. No derating shall be allowed.

5.2.7 Earthing of isolators and distribution transformer breakers (Earth Switch)

The unit shall consist of a 630A Tee Off spring assisted three position rotating arc type vacuum circuit breaker unit, with integral fault making/dead breaking earth switch, the function shall be naturally interlocked to prevent the off load disconnecter and earth switch from being switched 'ON' at the same time The operation of the main off load disconnecter and earth switch to be made by



lever/handle/operating rod with necessary interlocks as per IEC standards. CB should be operated ON/OFF irrespective of the earth switch position. However, CB operation should not affect the cable earthing done by earth switch.

The cables shall be earthed by an integral earthing switch with short-circuit making capacity, in compliance with IEC 60129 standard. The earthing switch shall be operable through the main circuit mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

5.2.8 Circuit Breaker (Vacuum)

The 3 pole circuit breaker for the protection shall be enclosed in the main tank. The rated breaking and making current at rated voltage shall be as follows:

For 11kV system:

- Rated breaking capacity shall be 25 kA.
- Rated short time current shall be 25 kA for 3 second.
- Rated making current shall be 50 kA.

Minimum number of operations at rated current (as per IEC 62271-100,102): Mechanical endurance M1 (2000), Electrical endurance-Class E2

Breaker status auxiliary contact: 2NO + 2NC wired to terminal block

Relay auxiliary contact for remote indication: Potential free contact 1 NO +1 NC wired to terminal block.

The circuit breaker shall be fitted with a self powered relay, which shall operate in the event of fault occurrences. The breaker indications ON and OFF positions shall be indicated by suitable flag. For ON position indication by Red flag and OFF position indication by Green flag shall be provided.

The circuit breaker shall be operated by the same unidirectional handle or switch. The rated operating sequence shall be O- 0.3S- CO-3min- CO.

The protection on the circuit breaker:

The circuit breaker unit fitted with 3 nos. protection CT's (tape wound) of ratio 100-50A/1A (may be changed as per site requirement), 5P10 class, having low burden and trip coil and auxiliary switch assembly allowing the use of a self- powered non-directional IDMT (Inverse Definite Minimum Time) Over Current and Earth Fault Relays (Microprocessor based numerical). One Three Element Relay having two O/C elements and one E/F element shall be provided for this purpose. All these relays shall be of 3 seconds IDMT characteristics, the O/C elements current setting variable from 20% to 200% of CT secondary ratings, and the E/F elements having current setting variable from 10% to 40%. The protection curves and all other settings shall be adjustable from touch panel.



5.2.9 Bushings

All the bushings shall be of same height, parallel, on the equal distances from the ground and protected by a cable cover. It is preferable to have bushings accessible from the rear side of the RMU.

5.2.10 Cable Boxes

All cable boxes shall be air insulated suitable for dry type cable terminations. The cable boxes at each of the two ring switches suitable HV cables of size 3C x 300 sq.mm and circuit breaker cable suitable up to 3C x 400 sq.mm. Cable size is indicative and should be read as per the requirement of the project.

For indoor Cable boxes should be front access and interlocked with earth switch. No rear access required. For outdoor RMUs cable boxes shall be on sides/rear/front.

5.2.11 Voltage Indicator Lamps and phase comparators

The RMU shall be equipped with a voltage indication. There should be a facility to check the synchronization of phases with the use of external device. It shall be possible for the each of the function of the RMU to be equipped with a permanent voltage indication as per IEC 601958 to indicate whether or not there is voltage on the cables. The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp must be used to indicate live cables.

Three outlets can be used to check the synchronization of phases with the use of an external device.

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC 61243.

5.2.12 Extensible

Each combination of RMU shall have the provision for extension by load break isolators / breakers in future, with suitable trenching chamber, accessories and necessary Busbars. Extensible isolators and circuit breakers shall be individually housed in separate SF6 gas enclosures. Multiple devices inside single gas tank / enclosure will not be acceptable. In case of extensible circuit breakers, the Breaker should be capable of necessary short circuit operations as per IEC standard i.e. 25 kA for 3 second for 11kV system. The Breaker should have a rated current carrying capacity of 630 A.

5.2.13 Fault Passage Indicators / Earth Fault Indicators (FPI/EFI)

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self- contained requiring no auxiliary power supply. The FPI shall be integral part of RMU.

Each RMU shall be provided with FPI in the isolator to indicate the short circuit and earth fault. The Unit shall be self-powered and requiring no auxiliary power supply. The fault shall be displayed / indicated by means of LCD / LED which can be reset with manual / auto with selectable time/ on



restoration of supply.

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU, shall be capable of displaying / indicating the fault. The FPI shall have LCD / LED display, automatic reset facility.

FPI Reset from SCADA will be through momentary closure of a potential free contact from FRTU. The FPI should be self-powered and should have internal lithium battery for external indication and setting of FPI in the absence of current.

The FPIs shall include:

- (a) Fault detection - Phase to phase and Phase to earth faults.
- (b) One potential-free output contacts for hardwiring to RTUs. On this basis, the SCADA/DMS will be able to monitor phase / earth fault condition.
- (c) Local fault indications – LED / LCD display on FPI front panel along with LED indication on front panel of RMU enclosure.
- (d) Multiple reset option –
 - (i) End of time delay (Adjustable from 2 to 16 Hrs.)
 - (ii) Remote reset (Via potential free input contact of FPI)
 - (iii) Manual reset (Reset button on front panel of FPI)
 - (iv) Automatic reset on current restoration.

The characteristics of the FPIs shall include:

- Phase fault thresholds configurable from at least 200 to 1000 A
- Earth fault thresholds configurable from at least 10 to 100 A
- Multiple number of steps for adjusting phase and earth fault thresholds.
- Fault current duration range configurable from at least 40 ms to 100 ms in 20 ms steps and further 100 ms to 300 ms in 50 ms steps.
- Variations with respect to these characteristics may be acceptable as long as they prove applicable and provide the same or better flexibility.

The sensors to be bushing / cable mounted. The number of FPI should be put in all the three phases of the outgoing branch of the RMUs.

FPI should have suitable connectivity with the FRTUs for the SCADA purpose.

The FPI inside the RMU should be communicable and hard wired to the TB for the signals



Fault Passage indicator OK

Fault Passage indicator operated

The practice is to have N numbers of FPI where N is number of LBS in a particular configuration of RMU.

Units fully SCADA Compatible. Retrofitting at site possible at a later date. Line switches (Load break switches) as well as T- OFF circuit Breaker can be operated by remote.

The RMU should have compatibility with MODBUS PROTOCOL SCADA system. The RMU shall provide DI/DOs for interfacing with FRTU. The protection relay shall have MODBUS protocol along with RS485 Port. Ring Main Units capable of being monitored and controlled by the SCADA/DMS.

FRTU, MODEM, Power and I/O cable interface between FRTU and Control panel of RMU's are in the scope of supply.

Cable testing possible without disconnection of cables.

Compact in dimension.

All live parts should be inside a hermetically sealed metalized Epoxy enclosure / stainless steel enclosure for outdoor type RMU & 3mm stainless steel robotically welded enclosure for indoor RMU.

5.2.14 Auxiliary Transformer

The RMU's shall be outfitted with an auxiliary transformer with its primary connected to the 11kV Bus voltage as applicable and the secondary providing a single phase 230V, 50 Hz nominal to supply the various loads that comprise the battery charger in the FRTU (supplied by others with rating of 230VAC, 1A), light fixture in the RMU, receptacle (230VAC, 5A for powering local test equipment's) and AC load within the RMU if any as per manufacturers design. The auxiliary transformer shall have a sufficient VA capacity (minimum 1000VA) of 150% of the load (load comprising of Battery Charger in FRTU plus RMU Power requirements) pertaining to the RMUs. The auxiliary transformer shall meet the applicable design standards as per IS/Equivalent standards.

5.2.15 Power Supply

Each RMU shall be fitted with a power supply, including batteries and battery charger, suitable for operating the motors of the On-load Isolators and Circuit Breakers. On this basis, the following operational specifications shall apply:

The power supply unit shall conform to the following requirements:

- Input : 230 V AC nominal from the RMU's auxiliary transformer allowing for possible variations from 190 to 300 V AC



- Output : Stable 24 V
- Batteries : 24 V (2 nos. of 12 V DC each)

The auxiliary transformer's inputs shall be equipped with surge protection devices in accordance with IEC 62305.

5.2.16 Battery

The Battery should be of reputed make with superior dry fit technology, maintenance free suitable for Automation of RMU. Following should be the features of the battery: -

Battery duty requirement - 24V, 20 AH plus the AH required for the 5 nos. of continuous opening and closing of all the three limbs (minimum 26AH battery). Further, Battery AH capacity should also be sufficient to take care the requirement of SDH equipment (-48V to be supplied through converter) as detailed in Telecommunication equipment section. Therefore, capacity of the battery in any case shall not be below 40 AH of Dry type, maintenance free batteries.

- (a) The position of the battery shall be kept at minimum heated area of the RMU
- (b) Exceptional energy storage capacity combined with long life.
- (c) Maintenance free (no topping up) during the whole service life.
- (d) Very low gassing due to internal gas recombination.
- (e) Short recharging time.
- (f) Completely recyclable.
- (g) Should have capacity for 5 Switching operations and 6 hours of operation of RTU / Modem / Communication for SCADA in the event of supply failure.

Battery provided in RMU for FRTU and communication purpose may be combined unit or separate units.

5.2.17 Battery Charger

24V online Rectifier cum battery charger of sufficient capacity to drive motors and SCADA equipment with voltage regulation of +/-5% or less on full load shall be provided. Battery charger, offered shall be suitable for Dry fit batteries with the following technical features:

- (a) Modular type battery charger.
- (b) Input voltage 230 V AC +/- 20%
- (c) Output voltage (as per requirement for the battery above).
- (d) Output adjustment range.
- (e) Series and parallel use should be possible.
- (f) The battery shall recharge to 80 % of its capacity in a maximum of 15 hours.



- (g) Batteries shall be disconnected at the manufacturer's specified minimum voltage.
- (h) Battery Low indication shall be available locally and remotely and shall include a battery test. The indication of "Battery Low" status shall allow for a further three RMU operations.
- (i) System Healthy and Power Fail indicators to be provided.
- (j) Technical specifications to be indicated by the bidder on the battery charger are:
- (k) The battery charger shall be fully temperature compensated.
- (l) To prevent deep discharge of the batteries or loss of AC power source, the battery charger shall automatically disconnect all circuitry fed by the batteries following a user-adjustable time period or when the battery voltage falls below a preset value. If the battery voltage falls below the preset value, the time to fully recharge all batteries shall not exceed twenty-four (24) hours.
- (m) An automatic battery checking device shall be provided to check the battery's health and initiate a battery-failed alarm signal in case battery deterioration is detected. Such detection may be based on comparing measurement values with set values (e.g., internal resistance, voltage, etc.).
- (n) The battery charger shall be provided with an alarm displayed at the local control panel and remotely at the SCADA to account for any of the following conditions:
 - Low battery voltage High battery voltage Battery failed
 - Battery charger overvoltage
 - Grounded battery/battery-charger
 - Others according to manufacturer's design

5.2.18 Motorization

All the functions within the RMU i.e. Isolators/Breakers should be fitted with motor mechanism and closing coil making it suitable to make it ON from remote. (However, manual mechanism should be possible in case of failure / non-working of motor)

Other Accessories (required with RMU):

- (a) Shunt Trip Coil (Coil voltage shall be indicated later on)
- (b) 4NO+4NC auxiliary contacts

5.2.19 Metering Arrangements

Technical specifications for the metering arrangement shall be referred to the Chapter of Metering Arrangements.

5.2.20 SCADA Connectivity

Provision shall be made in all the RMUs with necessary take off terminal units for automations and connectivity with FRTU. All RMUs shall be motorized type and compatible for SCADA operation. All the I/O signals need to be brought to the Terminal Strip on a Din Rail, also the Din Rail should have



space to mount the MFM's provided by SIA. All the DI's, AI's and DO's should be provided as potential free and control contacts. The CT/PT should provide metering grade core for connecting MFM (Multi function Meter) provided with FRTU. The RMU will also supply 230VAC 500VA for FRTU.

Multifunction meter (MFM) to be provided along with RMU which should have the provision of mapping all the signals with RS 485. These data shall further be sent to FRTU through Modbus RTU protocol for onward transmission to control center. Also, necessary wiring shall be provided to connect MFM.

The RMU should be provided with provision of following minimum signals available at separate SCADA terminal box:

Minimum Signals for SCADA- DMS	To be wired to Separate TBs	Indication
CB close / open	Potential free contacts -	Double Point
LBS close / open	Potential free contacts -	Double Point
LBS & CB Earth switch close / open	Potential free contacts -	Single Point
Spring charge Status Indication (For CB and LBS)	Potential free contacts -	Single Point
SF6 Gas pressure low	Potential free contacts -	Single Point
O/C operated	Potential free contacts -	Single Point
E/F operated	Potential free contacts -	Single Point
Local / Remote	Potential free contacts -	Single Point
Common power supply	Potential free contacts -	Single Point
Motor MCB healthy status	Potential free contacts -	Single Point
Battery Charger Fail	Potential free contacts -	Single Point
RMU Door open	Potential free contacts -	Single Point
CB Trip coil healthy	Potential free contacts -	Single Point
CT & PT	For SCADA Metering	-
FPI control	FPI remote resetting for SCADA -	Single command
CB control	Control from SCADA -	ON / OFF
LBS control	Control from SCADA -	ON / OFF

5.3 TESTING AND CERTIFICATION

5.3.1 Type Tests

Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298, 60420, 60529 and 60694. The following type tests must have been performed and made available

- Short time and peak withstand current test
- Temperature rise tests
- Dielectric tests
- Test of apparatus i.e. circuit breaker and earthing switch
- Arc fault test
- Measurement of resistance of main circuit
- Mechanical endurance test



- (h) Duty cycle test
- (i) Internal arc test for HT chamber
- (j) Degree of protection for IP54 for OUTDOOR and IP2X for INDOOR RMU

Type test reports for above type shall be submitted with the offer.

5.3.2 Routine Tests

Routine tests should be carried out in accordance with IEC 60298 standards. These tests should ensure the reliability of the unit.

Below listed test should be performed as routine tests before the delivery of units;

- (a) withstand voltage at power frequency
- (b) measurement of the resistance of the main circuit
- (c) gas leakage test
- (d) withstand voltage on the auxiliary circuits
- (e) operation of functional locks, interlocks, signalling devices and auxiliary devices
- (f) suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism
- (g) verification of wiring
- (h) visual inspection

5.4 DOCUMENTATION

An instruction manual should be provided with necessary information for receiving, handling, storage, installation, operation and maintenance.

Routine test certificate should follow each unit and standard schematic drawings should be delivered for Ring Main Units. Compact Switchgear should be having drawings that consist of system single line drawings, general arrangement and schematic drawings for order specific units.

All drawings shall confirm to International Standards Organization (ISO) "A" series of drawing sheets/Indian Standards Specification IS: 11065. All dimensions and data shall be in ink and suitable for microfilming. All dimensions and data shall be in S.I. Units.

5.5 LIST OF DRAWINGS AND DOCUMENTS

The Bidder shall furnish four sets of relevant descriptive and illustrative published literature, pamphlets and the following drawings for preliminary study along with offer.

- (a) General outline drawings showing dimensions and shipping weights, quantity of insulating



media.

- (b) Sectional views showing the general constructional features of the circuit breaker including operating mechanism, arcing chambers, contacts with lifting dimensions for maintenance.
- (c) Drawings showing control cabinets and circuit diagrams for operating mechanism. Schematic diagrams of breaker offered for control, supervision and auto reclosing. Structural drawings and loading data for support structures.
- (d) Foundation plan and loading data and foundation design.
- (e) Drawings showing the complete operation cycle of the RING MAIN UNIT with description.

5.6 NAME PLATE

Each RMU and its associated equipment shall be provided with following information.

- (a) Name of manufacturer
- (b) Type, design and serial number
- (c) Rated voltage and current
- (d) Rated frequency
- (e) Rated symmetrical breaking capacity
- (f) Rated making capacity
- (g) Rated short time current and it duration
- (h) Purchase Order number and date
- (i) Month and year of supply
- (j) Rated lightning impulse withstand voltage



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CHAPTER 6:

LT PANEL



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CHAPTER 6: LT Panel

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
6.1	General Requirement.....	1
6.1.1	Scope.....	1
6.1.2	Standards	1
6.1.3	Technical parameters.....	1
6.2	Description	2
6.2.1	Type of LT panel	2
6.2.2	Cubicle.....	2
6.2.3	Air Circuit Breakers (if provided)	4
6.2.4	Busbar	5
6.2.5	Fuse base assembly, if mentioned in the price schedule	6
6.2.6	Moulded Case Circuit Beaker (MCCB)	6
6.2.7	Painting.....	7
6.3	Tests.....	7
6.3.1	Type Test	7
6.3.2	Routine Test.....	7
6.4	Prototype Sample	7



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6.1 GENERAL REQUIREMENT

6.1.1 Scope

This specification covers design, manufacture, supply, delivery of LT distribution panel made out of CRCA sheet. The system shall be A.C. 3 phase, 4 wire, 415 V, 50 Hz with effectively grounded neutral.

It is not the intent to specify herein complete details of design and construction. The equipment offered shall conform to relevant standards with high quality and workmanship capable of performing continuous and satisfactory operations in the actual service conditions at site.

The Protective switchgear shall be as per the description mentioned in the Price Schedule. This chapter broadly covers the construction requirement of the panel and shall be read in conjunction with the item description mentioned in the Price Schedule.

Bidder shall have proven experience of 5 years of manufacturing of similar products and supplying to electrical utilities.

6.1.2 Standards

The standards to be applied for design, manufacture and tests shall include the following IEC Recommendations and/or equivalent internationally recognized standards. The specification shall be suitable for satisfactory operation under the tropical conditions.

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	:	Low Voltage Switchgear and control gear assemblies
(P1 & 2)		

6.1.3 Technical parameters

(a) Rated Supply Voltage	:	3 phase 4 wire, 415 V, 50 Hz
(b) Rated Current	:	150 A, 200 A, 300 A, 400 A, 500 A, 600 A, 800 A
		(As per item description mentioned the Price Schedule)
(c) Insulation level	:	1100 V AC 50 Hz Continuous
	:	2.5 kV for 1 Min
	:	2000 V DC
(d) Rated short circuit	:	40 kA



6.2 DESCRIPTION

6.2.1 Type of LT panel

Types of LT panel will be as per below mentioned table:

SI No.	Type of LT panel	Name of Type
1	5- way Distribution feeder pillar with 1 no ACB, 4 pole, 3phase, 415V, 800 Amps for incoming and 4 nos outgoing MCCBs (200A, 300A, 300 A, 400 A) 4 pole, 3phase, 415V, metering arrangement on incomer suitable for outdoor installation	A
2	5- way Distribution feeder pillar with 1 no ACB, 4 pole, 3phase, 415V, 600 Amps for incoming and 4 nos outgoing MCCBs (200A, 200A, 300 A, 300 A) 4 pole, 3phase, 415V, metering arrangement on incomer suitable for outdoor installation	B
3	5- way Distribution feeder pillar with 1 no ACB, 4 pole, 3phase, 415V, 800 Amps for incoming and 4 nos outgoing MCCBs (200A, 200A, 300 A, 300 A) 4 pole, 3phase, 415V, metering arrangement on incomer suitable for outdoor installation	C
4	6- way Distribution feeder pillar with 1 no MCCB, 4 pole, 3phase, 415V, 500 Amps for incoming and 5 nos outgoing MCCBs, 4 pole, 3phase, 415V, 200 Amps rating each, along with LT CTs and Multifunction meter for metering arrangement on incomer suitable for outdoor installation	D1
5	6- way Distribution feeder pillar with 1 no MCCB, 4 pole, 3phase, 415V, 400 Amps for incoming and 5 nos outgoing MCCBs, 4 pole, 3phase, 415V, 200 Amps rating each, along with LT CTs and Multifunction meter for metering arrangement on incomer suitable for outdoor installation	D2
6	5- way Distribution feeder pillar with 5 nos outgoing MCCBs, 4 pole, 3phase, 415V, 200 Amps rating each, suitable for outdoor installation	D3
7	3 phase, 4 Polc, 415 v, Distribution Service Pillar for LT. 150 Amps incoming MCCB, 1 no with busbars for upto 30 connection distribution service pillar suitable for outdoor	E

6.2.2 Cubicle

The cubicle of LT panel shall be made out of 12 SWG (2.642 mm thick) cold rolled M.S sheet steel. All panel edges and door edges shall be reinforced against distortion by rolling, bending etc. The complete cubical shall be rigid self-supporting and free standing. The enclosure shall be anti-corrosive, dust proof, rust proof, vermin and water proof, ultra violet stabilized and flame retardant property.

The LT panel shall have front and rear compartments. Front compartment shall be suitable for mounting protective switchgear and the rear for cable terminations. There may be requirement of access from front door only. Same shall be finalized during detailed engineering. Insulating Sheet of suitable thickness shall be provided for separation between front and rear compartments. The LT Panel shall have protective switchgear for incoming circuit and outgoing circuits.

The cubicles shall have centre lift up type slanting roof rain hood. The depth and width of the rain hood shall be at least 120% of the depth and width of the pillars. The doors shall not be detachable

after fixing the rain hood.

Standard General Arrangement of Air Circuit Breaker, MCCB, MCB, HRC fuse base with links, Link Disconnecter, Bus Bars, connecting links, Cable termination arrangement etc. inside the L.T. panels shall be shown in the drawing during detailed engineering.

The general overall dimensions of L.T. panel shall be suitable as per the site conditions. The supplier shall submit the design and drawing for approval. Prototype shall be constructed and inspected by the representative of NEA before production.

The cubicles shall be provided with water proof non-detachable hinged doors made from CRCA sheet of 3.15 mm thickness.

The doors shall be centrally closed with triple position locking arrangement and shall be operational with a common handle from outside the door. Movement of handle will lock the doors at centre, top & bottom. One central lock with brass levers shall be provided inside the door. Key way with suitable cover shall be provided on the door for operating the lock from outside. Two keys shall be supplied for each pillar. In addition, cleat arrangement shall be provided for putting two nos. of padlocks for each size of doors. Any other similar arrangement may also be considered for approval during detailed engineering.

Four Louvers (two on each side) shall be provided to LT panel. Louvers with stainless steel wire mesh shall be provided on both sides of the panel. Mounting of components inside the enclosure shall allow free air circulation keeping the clearances as per specification. This requirement shall further be reviewed during detailed engineering.

Suitable no. of detachable gland plates made up of 3.25 mm sheet steel material shall be provided in the cubicle at the bottom. Gland plate shall be provided with suitable size cable gland & with four screws for fixing the plate from inside. Size & no. of the glands to be provided will be intimated to the successful tenderer along with approval of drawings. Necessary double compression Gland & lugs shall be provided with the panel. For outgoing of LT service pillar composite gland shall be provided based on each type of consumer.

A bayonet lamp holder complying with switch, a three pin plug & socket with necessary fuses & wiring shall be provided inside the pillar on the front bottom portion of the shade near the neutral busbar.

Rigid stand made from M.S. angle shall be provided with the panel for mounting on foundation/pole. An alternative arrangement for mounting of panel directly on foundation through foundation bolt can also be provided. Foundation Bolt shall be included with the supply of plinth mounted LT Panel. Mounting arrangement shall be finalized during detailed engineering.

Two galvanized earthing Bolts shall be welded from inside and projecting outside of the box. Two Nuts with washers shall be provided on each bolt.

Enamelled name plate of the supplier, type of pillar and Tender Number & date shall be displayed on front door.



Enamelled Danger Board with “DANGER 400 VOLTS” mark shall be displayed on the left hand side of front and back doors.

Galvanized steel structure shall be included with the supply of plinth/pole mounted LT Panel.

Multi-function meter (MFM) along with all the associated accessories including CT shall be provided in the incomer of D1 and D2 type panel which shall have provision for following measurement functions on the MCCB:

i) 3 phase current; (ii) 3 phase voltage; (iii) kWh; (iv) kVAh; (v) Power Factor; (vi) Max. demand (kVA) and (vii) Fault History

The LT Panel having multifunction meter (MFM) shall be equipped with GPRS based MODEM to transfer measurement data from MFM to the remote smart meter server/distribution control center (DCC). The technical specification of the GPRM based MODEM is provided in another Chapter.

6.2.3 Air Circuit Breakers (if provided)

Air Circuit Breakers (ACB) of the following rating & technical specifications shall be provided for the Incomer of LT panel as per IEC60947-2.

ACB shall be of 400V, 50 HZ, 800/600A (as per actual requirement mentioned in the price schedule) with short time current rating of 40KA for 1 sec. Other technical details shall be as follows:

Sr. No.	Particulars	Requirements
1	Rated operational voltage at 50 Hz	400 V
2	Rated frequency	50 Hz
3	Current rating Amps	800/600 A rms
4	Rated insulation voltage at 50 Hz	1000 V
5	Number of poles	4
6	Mounting arrangement	Fixed type front mounting
7	Rated Ultimate Short circuit breaking capacity at 415 V, 50 Hz	40 kA rms
8	Rated Service Short circuit breaking capacity at 415 V, 50 Hz	40 kA rms
9	Rated short circuit making capacity at 50 Hz	40x2.1
10	Rated short time withstand current for 1 sec at 50 Hz,	40 kA rms
11	Line-load reversibility	Required
12	Category of utilization	B
13	Shutters on ‘Trip’ & ‘Close’ push button with sealing facility	Required
14	Accessory mounting	Accessories shall be front accessible plug in type. Accessories namely motor shunt trip & closing coil UVT etc. should be common for the entire range & shall be suitable for both AC & DC voltages.
15	Operating mechanism	Spring charging stored energy type
16	Mechanical life (Operating cycles)	20000
17	Electrical life (Operating cycles) per set of arcing contacts	5000



18	Indications	Breaker shall have following mechanical indication: 1. ON, 2. OFF, 3. TRIP, 4. SPRING CHARGES STATUS
19	Sensing	True RMS based
20	Type	Microprocessor based
21	Control Terminal	Control Terminal should be front accessible & minimum 25 pairs of contact shall be available. Minimum 10 Auxiliary NO / NC contacts shall be provided for electrical interlocking between ACBs.
22	Ambient temperature	Suitable for operation at 40 degree C
23	Protection required	following protection with selective ranges required.
23-a	Overload	Pick-up: 0.4 to 1.0 Time delay: 0.2 to 40 sec
23-b	Short Circuit	Pick -up: 2 to 10 Time delay: 20 to 400 msec
23-c	Instantaneous over current	Pick -up: 4 to 16 & OFF
23-d	Earth fault	Pick -up: 0.2 to 0.6 & OFF Time delay: 100 to 400 ms
24	Metering Required	Provision for following measurement functions shall be made on the ACB (i) 3 phase current (ii) 3 phase voltage (iii) kWh (iv) kVAh (v) Power Factor (vi) Max. demand (kVA) (vii) Fault History
25	Indication	Release shall give individual indication for each type of fault
26	Power	Release shall be self-powered & Independent of incoming supply
27	Safety	Local controls shall be secured by padlocking arrangement

The ACB cubicle shall be equipped with GPRS based MODEM to transfer measurement data from ACB to the remote smart meter server/Distribution Command and Control Center (DCC). The technical specification of the GPRM based MODEM is provided in Chapter 20.

6.2.4 Busbar

The bus bars shall be made up of electrolytic grade aluminium confirming to grade 63401 WP of IS: 5082.

The bus bars shall be painted with non-deteriorating type paint for full length as below.

- Epoxy red colour for top bus bar
- Epoxy yellow colour for middle bus bar
- Epoxy Blue colour for bottom bus bar

- Epoxy Black colour for neutral bus bar below bottom bus bar

In place of paint coloured sleeve may also be used. Size of the bus bar shall be as per the design test report.

Suitable insulated phase barriers of suitable thickness insulating material shall be provided between front and rear compartment, between adjacent set of phase and neutral bus bars and between doors and bus bars with firm fixing arrangements.

Minimum clearances shall be as per requirement of relevant standards.

Current density should not be more than 1A/mm² for Service pillar.

6.2.5 Fuse base assembly, if mentioned in the price schedule

Fuse bases shall be suitable for HRC fuse links and strips. All fuse bases shall be identical and interchangeable and shall be capable to carry rated normal current without exceeding safe temperature.

The base of the HRC Fuse shall be of non-tracking, heat resistant insulating porcelain material of superior electrical and mechanical properties equivalent to Dough Molding Compound (DMC).

The contacts shall be made up of electrolytic grade copper alloy with corrugated terminal pad and spring action to yield high contact pressure.

Thermostatic bimetal device shall be provided between terminal pad and bus bars and between terminal pad and cable terminals to prevent bimetallic deterioration.

The complete assembly shall be so fixed and secured that there shall be no turn, fall out displacement and vibration of any part during inserting and removal of fuses/Links. Load current reading, cable end connection etc.

6.2.6 Moulded Case Circuit Breaker (MCCB)

The MCCB shall be air break type and having quick make quick break with trip free operating mechanism.

Housing of the MCCB shall be of heat resistant and flame retardant insulating material. Operating handle of the MCCB shall be in front and clearly indicate ON / OFF / TRIP positions.

The electrical contact of the circuit breaker shall be of high conducting nondeteriorating silver alloy contacts.

The MCCB shall be provided with thermal / magnetic type bi-metal over load release and electro-magnetic short circuit protection device. All the releases shall operate on common trip busbar so that in case of operation of any one of the releases in any of the three phases, it will cut off all the three phases and thereby single phasing of the system is avoided.



The MCCB in the incoming circuit shall be provided with an earth fault relay. The MCCB shall provide two sets of extra auxiliary contacts with connections for additional controls at future date.

The in-coming cable should be connected to the terminals of the MCCB with Bi-metallic lugs preferably of Usha Martin make or similar standard, duly crimped with Die-less crimping tools. There should be a metallic/heat resistant insulating barrier between the individual MCCBs so that the heat generated during any fault inside the Box should not pass to the other MCCBs.

6.2.7 Painting

The cubicles shall be provided with anti-corrosive high quality RAL7032 colour paint from inside and outside to withstand the corrosive and humid atmosphere.

6.3 TESTS

6.3.1 Type Test

- (a) Verification of temperature rise limits as per IS: 8623.
- (b) Verification of short circuit strength at 40 kA for one second as per IS: 5039/1983/3623/1977 with latest amendments (Except Service Pillars).
- (c) Verification of degree of the protection as per IS: 13947 with latest amendment.

Type test reports shall be submitted along with the type test of auxiliary switchgears as per IEC.

6.3.2 Routine Test

Routine and acceptance tests as per relevant IEC or equivalent Standard shall be carried out at the original manufacturers' works on complete pillar and carried out on all boxes.

- (a) Overall Dimension Checking
- (b) Insulation Resistance Tests
- (c) High Voltage Test at 2500 V, 50 Hz AC for one minute

6.4 PROTOTYPE SAMPLE

The successful bidders should manufacture 1 No. of prototype LT panel as per the specification and keep ready at their works for the purpose of sample inspection and testing. The NEA at their option may sent a team of Engineers to the works.

The supplier shall conduct voltage withstand test and operations tests at the time of inspection.

The supplier shall prepare a prototype and offer the same for inspection and approval before taking up mass production.

All routine & acceptance tests and inspection of material shall be carried out at the place of manufacturer. The manufacturer shall offer the Inspector (representing the purchaser) all



reasonable facilities, free of charge at the time of Inspection.

The supplier shall offer inspection of the material at his works before dispatch. If required, the supplier shall also offer inspection of manufacturing painting and assembly processes and quality control system. If any material is not found in line with relevant specifications, the supplier shall carry out the modification and offer for re-inspection.

Inspection and acceptance shall not absolve the supplier of his responsibility to supply the material in accordance with the specifications.

The purchaser reserves the right to reject the material not confirming the relevant specifications.

CHAPTER 7:

UTILITY POLE (STEEL TUBULAR POLE)



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CHAPTER 7: Utility Pole (Steel Tubular Pole)

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
7.1	GENERAL	1
7.1.1	Scope.....	1
7.1.2	Technical parameters.....	1
7.2	General requirements	1
7.2.1	Types	1
7.2.2	Supply of material	1
7.2.3	Manufacture.....	2
7.2.4	Chemical Composition	2
7.2.5	Freedom from defects.....	3
7.2.6	Tolerance	3
7.2.7	Workmanship	3
7.2.8	Protection against corrosion	3
7.2.9	Earthing arrangements	4
7.2.10	Testing and inspection	4
7.3	Installation	4
7.3.1	Excavations	4
7.3.2	Pole Setting	4
7.3.3	Demolition (if applicable).....	5
7.3.4	Clean Up.....	5
7.3.5	Tree Cutting and Trimming.....	5
7.4	Pole Accessories	6
7.4.1	Steel Cross Arms and Bracing Angles and Flats.....	6
7.4.2	Pole Clamps	6
7.4.3	Steel Bolts and Nuts	7
7.4.4	Requirement	7
7.4.5	Tests	7
7.4.6	Technical Parameters	7



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7.1 GENERAL

7.1.1 Scope

This part covers the general requirement for steel tubular poles of circular cross section for overhead power lines.

These general requirements apply to tubular steel poles, made of steels of minimum tensile strength 410 MPa (Normal duty).

7.1.2 Technical parameters

For the purpose of this standard, the following definitions shall apply.

Breaking Load – The theoretical load which would produce at ground level a stress equal to the tensile strength in the material. This is only of theoretical interest. In reality, the elastic limit of the materials would be exceeded, and considerable deformation would occur before this theoretical load could be applied.

Load for Permanent Set – The maximum load which may be applied without producing at the gripping and a permanent set higher than specified. The permanent set measured at the point of application of this load shall not exceed 13mm.

Load for Temporary Deflection – The maximum load which may be applied without producing at the point of application of this load a temporary deflection exceeding 157.5mm.

Crippling Load – The load which is just sufficient to cause crippling of the pole.

Point of Application of Load – For the purpose of definitions, the load should be applied at right angles to the axis of the poles at a point 30cm below the top for poles of length up to and including 9m and at a point 60cm below the top for poles longer than 9m. The pole should also be considered planted to specified depth.

Lot – A collection of the poles of one designation manufactured by the same process under similar conditions of production and offered for inspection at a time.

Lot size – Number of poles in a lot

7.2 GENERAL REQUIREMENTS

7.2.1 Types

Tubular steel poles shall be of the Swaged type.

Tubular poles shall be designed and manufactured as per IS 2713 (Part-I&II) 1980 or equivalent international standard with up to date.

7.2.2 Supply of material

The general requirements relating to the supply of the material shall be laid down in IS: 1387 – 1967 or equivalent international standard.



7.2.3 Manufacture

The tubes making poles shall conform to grade YST 240 of IS: 1161-1979, except that manual metal arc welding process may also be used to make the tubes and the cold bend test need not be carried out.

For mechanical test the tubes shall be sampled in accordance with IS: 4711-1974 depending on the number of tubes in the lot to be inspected.

Swaged Poles – Swaged poles shall be made of seamless or welded tubes of suitable length swaged and joined together. No circumferential joints shall be permitted in the individual tube lengths of the poles. If welded tubes are used, they shall have one longitudinal weld seam only; and the longitudinal welds shall be staggered at each swaged joint.

Swaging may be done by any mechanical process. The upper edge of each joint shall be chamfered off at an angle of about 45. The upper edge need not be chamfered if a circumferential weld is to be deposited in accordance with 5.3.2

Unless swaging is done by special process such as rotary or longitudinal die swaging process circumferential weld shall be deposited at the upper end of the joint at a slope of approx. 45. This circumferential weld shall be deposited only after the poles are subjected and conforms to all the test requirements specified in this standard.

Pole shall be constructed as per detailed below:

Parameters		9 mtr Pole	11 mtr Pole
Section length	Bottom (m)	5	5.6
	Middle (m)	2	2.7
	Top (m)	2	2.7
Outside diameter and thickness of sections	Bottom (mm)	165.1x5.40	193.7x5.90
	Middle (mm)	139.7x4.50	165.1x4.85
	Top (mm)	114.3x3.65	139.7x4.50
Approx. weight of Pole (kg)		164	256

The lengths of joints on swaged poles shall be as below:

Outer diameter of smaller tube in joint (mm)	Length of Joint (mm)
114.3	300
139.7	350
165.1	400

Each pole shall have manufacturer's name, year of manufacturing, batch number and IS -2713 / equivalent standard marked in such a manner that all these details can be read after erection of the pole.

MS base plate of 300 mm x 300 mm x 6 mm thick shall be welded to the bottom of the pole.

7.2.4 Chemical Composition

The material when analysed in accordance with IS:228 (part-II) – 1972 and IS:228 (Part IX) – 1975 shall not show sulphur and phosphorus contents of more than 0.060 percent each.

7.2.5 Freedom from defects

Poles shall be well finished, clean and free from harmful surface defects. Ends of the pole shall be cut square. Poles shall be straight, smooth and cylindrical.

Top cap to be given to avoid entry of foreign particles or water.

7.2.6 Tolerance

Outside diameter – The poles shall be as nearly circular as possible and their outside diameter shall not vary from the appropriate value, except at the joint or step, by more than + 1.0 percent.

(1) Thickness

In the case of welded tubes, its thickness shall not fall below the thickness specified by more than 10 percent.

In the case of seamless tubes, the following tolerances on thickness shall apply

- (a) Where the ratio of the thickness to the outside diameter is more than 3 percent, - 12.5 percent of the specified thickness; and
- (b) Where the ratio of the thickness to the outside diameter is equal to or less than 3 percent; - 15 percent of the specified thickness.

(2) Length

The tolerance on the length shall be as follow:

~~(b)~~(a) _____ On the length of any section +40mm

~~(c)~~(b) _____ On the overall length of poles +25mm

(3) Weight

The mean weight for bulk supplies shall be not more than 5 percent below the calculated value. The weight of any single pole shall not fall below the calculated weight by more than 7.5 percent.

(4) Straightness

The finished pole shall not be out of straightness by more than 1/600 or its length.

7.2.7 Workmanship

When the tubes are made by manual metal welding, the welder employed shall be qualified.

The welded joints shall be of good quality free from scale, surface defects, cracks etc.

7.2.8 Protection against corrosion

The poles shall be fully galvanized.



7.2.9 Earthing arrangements

A through hole of 14mm diameter shall be provided in each pole at a height of 300mm above the planting depth or 200mm above muffin, whichever is higher. Other similar arrangement may also be considered during detail engineering

7.2.10 Testing and inspection

Pole should be tested and inspected as per relevant standard.

7.3 INSTALLATION

7.3.1 Excavations

All excavations made for the installation, or demolition, of facilities shall be accomplished in a timely manner according to the scheduled installation. Required excavations shall be opened, material installed, and backfill placed, as specified, in a continuing operation to the greatest extent practicable.

Any excavation left open during discontinuous construction which is accessible to the public or along public thoroughfare, shall be covered or barricaded, and marked by suitable visual means, to prevent a public hazard.

A suitable metal or rubber mat shall be used to cover the backfilled trenches to prevent the dust pollution. The mat shall be such that it can take the weight of the vehicles.

Excavations shall be properly located and sized for the intended use. Pole and stay plate/anchor excavations shall be correctly sized to retain undisturbed soil to the greatest extent consistent with the means of excavation. Pole holes shall be made by power-driven auger or by manual methods; power-driven shovel equipment shall not be used. Pole holes shall be excavated to the specified depth with no tolerance shallow and tolerance of ten (10) centimetres deep. The bottom of pole holes shall be undisturbed soil, gravel or rock. Stay plate holes shall be excavated by manual methods to specified depth with no disturbed soil in the direction of the anchor rod.

All excavations shall be backfilled with excavated material, or as specified for the installation. Backfill shall be free of foreign materials and shall be well tamped with excess backfill graded over the excavated area to prevent depressions resulting from eventual natural compaction. Large amounts of excess backfill shall be removed from the site by the Contractor if so directed by Employer. If so directed by Project, the Contractor shall provide suitable backfill materials for excavations where existing removed materials is insufficient, or inappropriate, to provide suitable grading of the excavated area.

7.3.2 Pole Setting

Poles shall be set in accordance with the relevant standard and Construction drawings provided.

Each pole shall be assigned a unique construction number at the time of structure staking for preliminary identification and preparation of structure Data Sheets (SDS).

Subsequent to the preparation and approval of SDS, and prior to provisional acceptance of a given line section, the Project shall provide the Contractor with unique permanent pole numbers. The Contractor shall then apply the specified permanent pole numbers to each pole with black oil-based paint in neat clear English letters and/or Arabic numerals.



Permanent pole numbers shall be applied in letters/numerals five (5) centimetres in height at a point on the pole 1.6 meters above ground level. Numbers shall be applied on the side of the pole facing the adjacent street or travelled way.

7.3.3 Demolition (if applicable)

The Contractor shall perform the removal of all existing facilities, if any, in accordance with the specific directions of the Employer. All materials removed shall remain the property of Project and the Contractor shall deliver all salvaged materials to the Project warehouse, or as specifically directed by the Employer.

All poles shall be removed by pulling the complete pole from the ground; poles shall not be cut off at the ground line. Holes shall be backfilled and compacted completely with sufficient added backfill piled above grade to prevent depressions being created by natural compaction. Backfill material shall be provided by the Contractor.

All conductor materials removed shall be returned to the Project. Methods of conductor removal shall be specified by the Project. If conductor is removed in the longest length practicable for future re-use, the said conductor shall be wound on empty conductor reels supplied by the Contractor, with the reels marked with the conductor size and approximate length. Different conductor sizes shall not be mixed on any reel. If conductor is removed from structures and specified as scrap, conductors may be cut down in lengths and made up in rolls. Conductor sizes for scrapping may be mixed; different conductor metals shall be separated.

Care shall be taken in removing, handling, and transporting cut-outs, and surge arresters to minimize porcelain damage.

Transformers removed from service shall be delivered to the Project warehouse or as specifically directed by the Employer. Care shall be taken in removing, lifting, and transporting transformers.

Other structures shall be removed, such as concrete transformer pedestals in the most appropriate manner, as specified by the Project. Existing stay rods may be cut 20 centimetres below finished ground level.

7.3.4 Clean Up

The Contractor shall ensure that all worksites shall be free from all manner of debris resulting from the construction activity.

All crating, cable and conductor reels, packaging materials, conductor scraps, and other miscellaneous items are removed from the workplace. All holes resulting from removal of facilities shall be filled. If trees or bush have been cut or trimmed, all cuttings shall be removed. The worksites shall be left in clean natural conditions.

Site clean-up shall be an integral part of the Provisional Acceptance process, and no line section shall be provisionally accepted unless all clean-up work has been accomplished.

7.3.5 Tree Cutting and Trimming

Any tree cutting or tree trimming authorized and directed shall be accomplished by the Contractor under the direct supervision of Project.

All cutting shall be removed by the Contractor with disposition of cutting as specified by Project.



7.4 POLE ACCESSORIES

7.4.1 Steel Cross Arms and Bracing Angles and Flats

The steel cross-arms and bracing angles and flats shall be fabricated from hot-rolled channels and angles.

The steel channels, angles and flats shall be fabricated and tested in accordance with Indian Standards IS: 226-1975 and IS-808-1964 or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable. The minimum tensile strength of the steel shall be 4200 kg/cm².

The steel cross-arms and bracing angles shall be of sizes shown in the Table 1: Cross-arms, bracing angles and flats, contained herein.

Conceptual hole pattern and size of holes on cross-arm channels are shown in appropriate drawings herein, however, the Supplier must confirm with the Project the locations and sizes of holes prior to the manufacture.

The surface of the steel shall be flat after drilling or (punching) and free of dimpling or imperfections. The hole edges shall be broken by reaming. The holes shall be full dimension after galvanizing and no minus tolerance of specified hole size will be accepted.

The steel cross-arm and bracing angles & flats shall be furnished reasonably smooth on all surfaces and free of burrs or sharp projections.

The brace shall have a minimum tensile strength of 3182 kg at the bolt-hole and bolt slot.

The brace shall be capable of being bent 10 degrees at the bolt hole or slot and 140 degrees at any point between hole and slot without cracking of the base metal on the outside of bent portion.

7.4.2 Pole Clamps

The pole clamp shall be fabricated out of hot-rolled steel flat.

The steel flat for pole clamp shall be fabricated and tested in accordance with IS 226-1975 and IS 1731-1971 or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable. The minimum tensile strength of the steel shall be 4200 kg/cm².

Outline details of pole clamps are to be approved by the Employer. Dimensions may be changed to comply with the final pole sizes selected. Therefore, the dimensions must be confirmed with the Employer prior to manufacture.

The fittings shall be free of burrs, splinters, splits, sharp points and edges, which may damage conductors or show evidence of poor workmanship.

The surface of the steel shall be flat after drilling or (punching) and free of dimpling or imperfections. The hole edges shall be broken by reaming. The holes shall be full dimension after galvanizing and no minus tolerance of specified hole size will be accepted.

The pole clamps shall have a minimum tensile strength of 3182 kg at the bolt-hole and bolt slot.



7.4.3 Steel Bolts and Nuts

The bolts and nuts shall be manufactured and tested in accordance with IS: 1363 (Part I)-1984 or the latest version thereof or any other national or international standards that ensures at least equal or better quality to the standard mentioned above, will also be acceptable.

Bolts and nuts shall be furnished in the types, strength, diameters and lengths as specified and required for fixing the cross-arms, bracing angle & flats and pole clamps. However, the dimensions and length of threading of bolt must be confirmed with the Project prior to manufacture.

Thread forms shall be consistent with all material/items listed herein and shall not strip or slip under sustained tensile loading equal to the design tensile strength of the threaded material item.

7.4.4 Requirement

The pole accessories shall be galvanized with minimum thickness of 90 microns after fabrication in accordance with IS: 2629-1985 or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable.

Spring washers shall be electro galvanized.

7.4.5 Tests

Apart from the tests indicated herein in the referenced standards, the pole accessories shall undergo following tests:

- Visual Inspection;
- Verification of Dimensions;
- Verification of Galvanization thickness

7.4.6 Technical Parameters

Se. No.	Description	Type	Dimension in mm
1	11 kV Line Single Pole		
1.1	Cross Arm Pole Top	ISMC 100	300
1.2	Cross Arm Standard	ISMC 100	1200
1.3	Brace	Flat	40x6x660
2	11 kV Line H Pole		
2.1	Cross Arm Standard	ISMC 100	2390
2.2	Bracing angle	ISA	50x50x6x2723
2.3	Bracing angle	ISA	50x50x6x2071
3	11 kV Line Offset		
3.1	Cross Arm	ISMC 100	1700
3.2	Brace	Flat	40x6x877

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CHAPTER 8:

PORCELAIN INSULATORS AND FITTINGS



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CHAPTER 8: Porcelain Insulators and Fittings

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
8.1	General	1
8.1.1	Scope.....	1
8.1.2	General Requirement of Insulators	1
8.1.3	General Requirement of Disc Insulators fittings	1
8.1.4	General Requirement of Insulator Pins	2
8.2	Specific Requirements	2
8.2.1	Pin Insulator	2
8.2.2	Disc Insulator	2
8.2.3	Stay Insulator	3
8.2.4	Insulator Pins	3
8.2.5	Disc Insulator Fittings.....	4
8.3	Marking	4
8.4	Tests.....	4
8.4.1	Documentation.....	4



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8.1 GENERAL

8.1.1 Scope

This Specification covers the Type Test, fabrication and supply of pin insulators, disc insulators stay insulators, disc insulator fittings and insulator pins as herein specified for use on overhead power line construction.

8.1.2 General Requirement of Insulators

Insulators shall be fabricated and tested in accordance with the Standards referenced for each type of insulator or equivalent standards.

The Type Test shall be conducted in the recognized laboratory.

Porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed. The glaze shall be brown in color. The glaze shall cover all exposed parts of the insulators.

The design of insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. The porcelain shall not engage directly with hard metal.

The cement used in construction of insulators shall not give rise to chemical reaction with metal fittings and its thickness shall be as uniform as possible.

The insulators should be manufactured in automatic temperature-controlled kilns to obtain uniform baking and better electrical and mechanical properties.

8.1.3 General Requirement of Disc Insulators fittings

The disc insulator fittings shall be designed, manufactured and tested in accordance with IS: 2486 or any other national or international standards that ensure at least equal or better quality to the standard mentioned above, will also be acceptable.

The disc insulator fittings shall be supplied with ball and socket couplings and twisted straps. The insulator fittings shall conform to the shape and dimension as per the governing standards

Disc insulator fittings like ball and socket, nuts and bolts shall be made of hot rolled steel and the twisted cross arm strap shall be made of MS sheet metal. Cotter bolts and U-bolts shall be of galvanized steel. Cotter pins shall be of stainless steel.

All forgings and castings shall be of good finish and free from flaws and other defects. The edges on the outside of fittings, such as the ball socket and holes, shall be rounded. The nominal dimensions of the ball and socket, ball eye and twisted cross arm straps, shall be as per the governing standards.

All ferrous fittings and the parts other than those of stainless steel, shall be hot dip galvanized as per IS: 2629 or equivalent international standards.



8.1.4 General Requirement of Insulator Pins

The insulator pins specified herein shall be fabricated from hot rolled steel. The pin shall be a single piece obtained preferably by the process of forging. It shall not be made by jointing, welding, shrink fitting or any other processes from more than one piece of material. It shall be of good finish free from flaws and other defects. The finish of the collar shall be such that a sharp angle between the collar and the shank is avoided.

All ferrous pins, nuts and washers except those made of stainless steel shall be hot dip galvanized. The threads of nuts shall be cut after galvanizing and shall be well oiled and greased. The galvanizing shall conform to IS 2629-1985 or equivalent national or international standard.

All insulator pins shall be reasonably smooth on all surfaces and free of sharp projections.

8.2 SPECIFIC REQUIREMENTS

8.2.1 Pin Insulator

The pin insulator shall be manufactured and tested in accordance with IS: 731 and IS:3188 or the latest version thereof or any other national or international standards that ensures at least equal or better quality to the standard mentioned above, will also be acceptable. The lead thread shall be compatible with the insulator pin specified in these documents.

The pin insulator shall have following ratings and features:

Se. No.	Description	Unit	11 kV pin Insulator
1	Highest System Voltage	kV	12
2	Rated Voltage	kV	11
3	Creepage Distance (minimum)	mm	265
4	Wet power frequency withstand voltage	kV	35
5	Impulse withstand voltage	kV	75
6	Puncture power frequency voltage (minimum)	kV	105
7	Visible discharge voltage (Effective)	kV	9
8	Cantilever Strength	kN	5
9	GI pin head		Small

8.2.2 Disc Insulator

The disc insulator shall be manufactured and tested in accordance with IS: 731 or latest version thereof or any other national or international standards that ensures at least equal or better quality to the standard mentioned above, will also be acceptable.

The disc insulator shall be ball and socket fitting type. The disc insulator shall have the following ratings and features:



Se. No.	Description	Unit	11 kV Disc Insulator
1	Highest system Voltage	kV	12
2	Rated Voltage	kV	11
3	Porcelain Diameter (minimum)	mm	255
4	Spacing	mm	145
5	Creepage Distance (minimum)	mm	320
6	Power Frequency Puncture withstand Voltage		1.3 x Actual dry flashover voltage
7	Wet Power Frequency Withstand Voltage	kV	35
8	Impulse Withstand Voltage	kV	75
9	Puncture Power Frequency Voltage (minimum)	kV	105
10	Visible Discharge Voltage	kV	9
11	Mechanical Strength	kN	45 (70 for long span)
12	Ball and Socket Size		16 mm B
13	Applicable Standard for Special Characteristics		IS: 3188

8.2.3 Stay Insulator

The stay insulator shall be manufactured and tested in accordance with IS: 5300 or latest version thereof or any other national or international standards that ensures at least equal or better quality to the standard mentioned above, will also be acceptable.

The stay insulator shall have the following ratings and features:

Se. No.	Description	Unit	11 kV pin Insulator
1	IS Designation		A
2	Length	mm	90
3	Diameter	mm	65
4	Cable Hole Diameter	Mm	16
5	Creepage Distance (minimum)	mm	41
6	Minimum failing load	kN	44
7	Power Frequency Withstand Voltage		
7.1	Dry	kV	18
7.2	Wet	kV	8

8.2.4 Insulator Pins

The insulator pins to be supplied shall conform to IS: 2486 or equivalent international standards and to the shape and dimensions shown in the drawings contained in this specification. The insulator pin shall be furnished with a spring steel split lock washer and nut assembled on the insulator pin. The ratings and features of the insulator pins shall be as follows:

Se. No.	Description	Unit	11 kV pin Insulator
1	Head Type		Small S 165P
2	Total Length	mm	315
3	Stalk Length	mm	165
4	Shank Length	mm	150



5	Minimum Failing Load	kN	5
6	Applicable Standard		IS: 2486 or equivalent international standard.

The insulator pins shall be compatible with the insulators specified above

8.2.5 Disc Insulator Fittings

Disc insulator fittings like Ball and socket, nuts, bolts shall be made of hot rolled steel and the twisted cross arm strap shall be made of MS sheet metal. Cotter bolts and U-bolts shall be of galvanized steel. Cotter pins shall be of stainless steel.

All forgings and castings shall be of good finish and free from flaws and other defects. The edges on the outside of fittings, such as the ball socket and holes, shall be rounded. The nominal dimensions of the ball and socket, ball eye and twisted cross arm straps, are given in Drawings. The ultimate strength of the fittings shall not be less than 41 KN. In case of long span (more than 60 m), it shall not be less than 70kN.

All ferrous fittings and the parts other than those of stainless steel, shall be hot dip galvanized as per IS: 2629-1985 or equal internationally recognized standards.

8.3 MARKING

Each Insulator shall be legibly and indelibly marked to show the following:

- (a) Name or trademark of manufacturer.
- (b) Year of manufacture.
- (c) Minimum failing load in Newton
- (d) Name of Employer

Markings on porcelain shall be printed and shall be applied before firing.

8.4 TESTS

The insulators and fittings shall comply with the type tests and routine tests as per relevant governing standards.

8.4.1 Documentation

The Contractor shall provide certified type test results of pin insulator and insulators pin as required by governing standards.

The Contractor shall provide standard catalogue and certified dimensional drawings of pin insulator and insulator pins.

A clause-by-clause commentary on specification, specifying compliance and deviations, if any.

All data, drawings, catalogues and other technical documents shall be provided from the Contractor



CHAPTER 9:

GANG OPERATED LOAD BREAK SWITCH



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CHAPTER 9: Gang Operated Load Break Switch

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
9.1	General Requirement	1
9.1.1	General	1
9.1.2	Applicable Standards	1
9.2	Design Requirements	1
9.2.1	General	1
9.2.2	Particulars of System	1
9.2.3	General Technical Requirements	2
9.2.4	Switch Insulation	2
9.2.5	G.O Switch Operation and Operation Mechanism	2
9.2.6	Bearing or Rocker	3
9.2.7	Design Feature	3
9.2.8	Current Carrying Parts	3
9.2.9	Name Plate and Marking	3
9.2.10	Completeness of Equipment	4
9.2.11	Testing	4
9.2.12	Packing and Transportation	4



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9.1 GENERAL REQUIREMENT

9.1.1 General

This specification covers the technical requirements of design, manufacture, testing at manufacturer's works, packing and forwarding, supply and unloading of 11 kV, 400 Amps Air Break Gang Operated Double Throw Triple Pole Switch at site / stores complete with all accessories for efficient and trouble free-operation. The specific requirements are covered in the enclosed technical data sheet. The switches shall be used on three phase 11kV 50 Hz A.C. Power system having solidly grounded neutral.

9.1.2 Applicable Standards

Gang Operated Load Break Switch shall comply with following IEC standards. However, material manufactured as per any other international standards of equivalence or better shall be acceptable.

IEC 60129	:	Alternating current disconnectors and earth switches
IEC 60265-1	:	High voltage switches - Part 1: Switches for rated voltage above 1kV and less than 52kV
IEC 60694	:	Common specifications for high-voltage switchgear and control gear standards

9.2 DESIGN REQUIREMENTS

9.2.1 General

Gang Operated Load Break Switch shall be 11 kV, 400 Amps, double throw, triple pole gang operated, outdoor type, single break tilting type manual and motorized remotely operated.

It shall be suitable horizontal mounting on structures 6 meters above ground level fitted with 3 no. 11 kV Post Insulators per phase, i.e. 9 no. Post Insulators per switch of standard make conforming to latest versions of relevant international standards or IEC complete with fixed & moving contacts base of gun metal cast, duly electroplated and jaw (U) fixed with spring able strips.

The middle movable contacts arms rotate on rocker or bearing and blades will be made of gunmetal/brass/copper casting, duly electroplated. Multi- bolt type clamps of non-ferrous metal will be provided for incoming and outgoing connections. Fixed and moving contacts fitted on 11kV Post Insulators.

Phase coupler will be of 32mm diameter galvanized iron pipe. Operating rod shall be of 25 mm inner diameter and 32 mm outer diameter G.I. Pipe having free length of about 4 meter excluding the length of handle.

The complete equipment shall be as per latest version of IEC. MS Channel, C.I. casting for lever and side plates are to be hot dipped Galvanized as per relevant standard.

All other ferrous parts including nuts, bolts and washers are to be hot dipped galvanized. All Current carrying nuts, bolts and washers are to be hot dipped galvanized. The equipment supplied shall also conform to detailed specification with guaranteed technical particulars.

9.2.2 Particulars of System

The switches shall be used on three-phase 11 kV, 50 Hz Power system having solidly grounded neutral.



9.2.3 General Technical Requirements

Se. No.	Description	Requirement
1.	Installation	Outdoor
2.	Type	Double Throw Triple Pole
3.	Service Voltage	11 kV
4.	Rated Voltage	12 kV
5.	Rated Frequency	50 Hz
6.	Current Carrying Capacity	400 Amps
7.	Rated Short Time Current	25 kA for 3 sec
8.	Rated Peak Current in Closed Position	46 kA
9.	One minute power frequency withstand voltage between (i) Earth & Pole (ii) Across terminal of open switch	28 kV (r.m.s) 32 kV (r.m.s)
10.	Rated lightning impulse withstand voltage between (i) Earth & Pole (ii) Across terminal of open switch	75 kV (r.m.s) 85 kV (r.m.s)
11.	No. of Post per Phase	3

9.2.4 Switch Insulation

Insulation to ground, insulation between open contacts and insulation between phases of the completely assembled G.O. Switches shall be capable of withstanding the dielectric test voltages specified in IEC.

Insulation between open contacts of a pole shall at least be 15 % more than the insulation between the live parts of pole to ground, so that If any flash- over occurs when switch is open, it shall be to the ground. All insulators provided to form a stack shall conform to the relevant IEC or equivalent international standard. The porcelain shall be homogeneous and free from all cavities and flaws. The design of insulators shall ensure ample insulation, mechanical strength and rigidity for satisfactory operation under site conditions. The design shall also ensure that the losses caused by capacitive current or conduction through dielectric are minimum and that leakage due to moist and dirty insulators surfaces is least.

All metal caps and supports shall be cemented to the porcelain whereas the blades and contact blocks shall be bolted to the metal parts of the insulators thus making the replacement of damaged insulators easy. All ferrous metal parts, flanges, bolts and nuts etc. shall be galvanized.

The porcelain post insulators should be from the leading manufacturers.

9.2.5 G.O Switch Operation and Operation Mechanism

The switches shall be suitable for local manual / electrical and remote motorized operation. The Operating mechanism shall comprise of operating pipe with intermediate couplings and manual operating handle.

Height of operating handle may vary from 1000 to 1300mm. The operating mechanism shall give good mechanical leverage with minimum loose/lost motions. There shall be suitable pad-locking arrangement for both 'ON and OFF' positions.

The GO Switch shall be suitable for remote operation through SCADA via Optical Fibre or GPRS.



Therefore, suitable communication facility like FRTU etc. shall be provided, within the operating mechanism box. The specification of FRTU mentioned in the RMU chapter shall be referred for this FRTU also.

AC Supply shall be extended to FRTU by tapping the existing LT line by the Contractor after finalization of the tapping arrangement by NEA/Consultant.

The materials, like conductor/Cable lugs etc, required for taping AC supply shall be included as accessories of the GO switch.

9.2.6 Bearing or Rocker

Graded cast rocking type levers supported on side plates/fabricated type, Bearing housing shall be weather proof and facilities shall be provided for easy lubrication.

9.2.7 Design Feature

(1) Contact System

The male and female contacts assemblies shall be of sturdy construction and design to ensure:

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

(2) Contact System

Maximum temperature attained by any part of the isolating switches when in service at site under continuous and exposed continuously to the direct rays of sun and the air having temperature of 40 degree centigrade shall not exceed the permissible limits fixed by latest edition of IEC. Maximum temperature rise under the above noted condition should not exceed the permissible limits when corrected for the difference between ambient temperature at site and the reference ambient temperature.

9.2.8 Current Carrying Parts

All current carrying parts shall be of non-ferrous metal or alloys and shall be designed to limit sharp point edges. Design of isolating contacts shall permit easy maintenance and renewal of contacts.

9.2.9 Name Plate and Marking

The Air Break GO Switch shall be provided with durable and legible name plate, effectively secured against removal. The name plate shall be indelibly and distinctly marked with all essential particulars as per the relevant standards along with the following:

The Name plate shall be embossed with tender number with date & "PROPERTY OF NEA".



1. Continuous operating Voltage
2. Rated Voltage
3. Rated Frequency
4. Manufacturer's Name
5. Type and Identification of the complete arrester
6. Month/ Year of Manufacture
7. Serial Number
8. Order reference
9. Rated normal current in Amps
10. Rated one second short-time current in Amps

9.2.10 Completeness of Equipment

All fittings, accessories or apparatus which may not have been specially mentioned in this specification, but which are otherwise necessary for satisfactory working of GO Switches shall be deemed to have been included in the scope of supply.

9.2.11 Testing

It shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & type test reports shall be submitted for Employer's approval.

Routine tests as per latest edition of IS-9921 (part-I to V) shall be carried out at works of the manufacturer.

The following shall comprise Routine tests:

- (a) Power frequency voltage dry test
- (b) Measurement of the resistance of the main circuit
- (c) Operating Test

Copies of Routine test certificates shall be supplied along with the acceptance tests carried out in the presence of purchaser's authorized representative. All tests reports shall be submitted and shall be got approved by the purchaser or his authorized representative before dispatch.

9.2.12 Packing and Transportation

The supplier shall be responsible for suitable packing of all the material and marking on the consignment to ensure correct dispatch to the destination. All G.O. Switches shall be packed suitably capable of withstanding rough handling for transportation to the various consignees so as to avoid any shortage and damage occurring during transit. Separators shall be fixed between the post insulators and other breakable parts of GO Switch and also between individual GO Switches so as to prevent relative movement to avoid damage. All the labels used on each packing shall be of tin securely bounded with wire and shall have the descriptive marking stamped thereon. All GO Switches damaged during transportation shall be to the supplier's account.



CHAPTER 10: **LIGHTNING ARRESTER**



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CHAPTER 10: Lightning Arrester

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
10.1	General Requirement.....	1
10.1.1	General	1
10.1.2	Standards	1
10.1.3	Location to be installed	1
10.2	Design Requirements	1
10.3	Test.....	1
10.4	Drawing and Data.....	2
10.5	Name Plate	2



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10.1 GENERAL REQUIREMENT

10.1.1 General

This specification covers the design, manufacture, factory test, delivery, field test and installation of lightning arresters, complete with all accessories.

Manufacturer of instrument transformer shall hold valid ISO 9001(including design) quality certificate.

10.1.2 Standards

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60099-4	:	Metal-oxide Surge arrester without gap for A.C. system
IEC 60099-5	:	Surge arrester - Selection and application recommendations
IEC 60529	:	Degree of protection provided by enclosures

10.1.3 Location to be installed

Lightning Arrester shall be installed to each phase of the following locations

- On the HV bushing of Distribution Transformer
- Tipping point (Cable Terminal) from Underground cable to Overhead conductor
- To line and load side of automatic reclosure.

10.2 DESIGN REQUIREMENTS

The lightning arresters shall be pole mounted type, single pole, gap less type rated voltage 9 kV for 11 kV system. The nominal discharge current shall not be less than 10kA for station class and 5 KA for distribution class lightning arrester.

The active part of the lightning arresters shall be accommodated in porcelain insulators which are suitably reinforced to prevent explosion of an arrester.

Pressure relief device shall be provided for the safe discharge of internal pressure.

The lightning arresters shall be mounted on galvanized steel structure or pole. Terminal connectors for both line and ground terminals shall be furnished.

10.3 TEST

It shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & type test reports shall be submitted for Employer's approval.

All routine tests shall be performed on each piece of arrester as per IEC. In addition, the following tests shall be carried out.

- Construction test
- Insulation resistance test and leak current test



Type test certification on similar equipment and routine test certificate carried out for following test shall be furnished for approval of the Employer/Employer's Representative.

- (c) Voltage withstand test
- (d) Impulse voltage characteristic test
- (e) Discharge voltage characteristic test
- (f) Discharge current withstand test
- (g) Duty cycle test
- (h) Pressure relief test
- (i) Contamination test

10.4 DRAWING AND DATA

The following drawings and data shall be furnished in required number of copies after award of contract for approval of Employer/Employer's Representative.

- (a) Standard catalogue identifying the models and rating being furnished.
- (b) Outline drawing including dimensions.
- (c) Outline drawings including dimensions
- (d) Transport/shipping dimension with weight
- (e) Any other relevant data, drawings and information

10.5 NAME PLATE

Each lightning arrester shall be provided with a nameplate of weather resistant material fitted in a visible position showing the following items as a minimum.

- (a) Manufacturer's name
- (b) Manufacturer's serial number and type designation
- (c) Year of Manufacture
- (d) Rated voltage
- (e) Nominal discharge current



CHAPTER 11:

STEEL LATTICE TOWERS



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CHAPTER 11: Steel Lattice Towers

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
11.1	General	1
11.1.1	Scope.....	1
11.1.2	Material	1
11.2	Design.....	1
11.2.1	Design Criteria	1
11.2.2	Design Temperature.....	1
11.2.3	Design Parameters	2
11.2.4	Assumed Normal Working Loads.....	2
11.2.5	Erection Loads.....	2
11.2.6	Thickness of Members.....	2
11.2.7	Slenderness Ratio.....	3
11.3	Construction of Tower Steelwork.....	3
11.3.1	Step-bolts.....	3
11.3.2	Workmanship	3
11.3.3	Member fabrication-galvanising	4
11.3.4	Bolts and nuts	4
11.4	Tower Earthing	5



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11.1 GENERAL

11.1.1 Scope

The specification covers the design, fabrication, testing, supply and erection of Steel Lattice Towers complete set as per the design data provided in the specification.

The towers shall be self-supporting, hot dip galvanized, latticed steel type & designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

The tower shall be fully galvanized using mild steel or/and high tensile steel sections as specified in the Specification. Bolts and nuts with spring washer are to be used for connections.

11.1.2 Material

IS Steel Sections of tested quality of conformity with IS: 2062:2011 grade E250 (Designated Yield Strength. 250 MPa) and/ or grade E350 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stubs and stub setting templates. For Snow Zone towers MS & HT Steel Sections shall conform to E250 Grade-C & E350 Grade-C respectively. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards viz BSEN 10025. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

The material of towers must be galvanized steel conforming to BS 4360 Gr-43A or equivalent standard.

11.2 DESIGN

The towers are intended to be used for very long spans which cannot be crossed by normal poles arrangement like valley and river crossings etc. The angle towers shall be proposed. These Towers shall be developed as per the site requirement.

11.2.1 Design Criteria

Towers shall be designed based on spans and clearances as per as per the standards and requirements and loading conditions as per the site.

The design of support, conductors, insulators and fittings shall be such as to minimize the risk of damage or deterioration in service of any part of the transmission lines due to vibration.

The calculation procedures applied for support and foundation design shall be submitted by the Contractor in the detailed design stage.

11.2.2 Design Temperature

The following temperature range for the conductors and ground wires shall be adopted for line design:

- (a) Minimum Temperature : 0°C
- (b) Everyday temperature of conductor : 32°C
- (c) Max. temperature of



- (d) Conductor : 75°C(ACSR), 90°C(AAAC)
- (e) Earthwire exposed to sun : 53°C

11.2.3 Design Parameters

The following data must be incorporated in the design of the Towers. A detail design and drawing of tower and that of the foundation must be submitted to the Employer for prior approval. The exact site requirements shall be identified during the pre-construction survey and approval of drawings and route.

Se.No.	Description	Data
1	Factor of Safety	2
2	Design span or normal ruling span of Towers	Minimum 100 m
3	Wind Span and Weight span of Conductor	1.5 times of span
4	Minimum ground Clearance from the bottom conductor	As per relevant standard
5	Wind Zone	4
6	Circuit on Towers	Single
7	Angle of Deviation	As per site condition
8	Phase to Phase Clearance Horizontal Vertical	As per site condition
9	Disc Insulator	As necessary
10	Conductor	AAAC or ACSR-DOG

11.2.4 Assumed Normal Working Loads

The assumed maximum simultaneous working loading on special branch tower shall be as follows:

- (a) Vertical loadings - The weights of insulators and all other fittings and the actual dead weight of specified span lengths of line conductor and GW.
- (b) Transverse loadings - The specified wind pressure at right angles to the conductors on the whole projected area of the conductor, insulators and GW.
- (c) In addition, the transverse and horizontal components of the maximum conductor and GW tensions resolved for the maximum angle of deviation concerned.
- (d) Longitudinal loading - the full maximum longitudinal conductor and GW tensions given on one side only of the tower in longitudinal direction and no conductors and GW strung on the other side of tower, together with a plan angle of entry on the line side up to 15 degree equivalent to 30 degree line deviation.

11.2.5 Erection Loads

The Contractor shall fully consider the loading conditions for the towers and provide adequate margins of strength in the designs for unbalanced erection loading. The Contractor shall indicate on drawings to which points on the towers to be proposed to use back stays when stringing conductors and shall state what factors of safety are obtained under these conditions

11.2.6 Thickness of Members

The minimum thickness of angle sections used in the design of towers, unless otherwise specified



elsewhere in this Specification, shall be kept not less than the following values:

- (a) Main corner leg members including the earthwire peak and main cross arm : 5 mm
- (b) For all other members : 4 mm

11.2.7 Slenderness Ratio

Slenderness ratio for members shall be computed in accordance with the relevant standards. The following maximum limit of the slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration will be adopted:

11.3 CONSTRUCTION OF TOWER STEELWORK

All designs shall be such that no trouble shall arise in service from vibration or excessive deflection due to the use of very light section.

Bolt holes shall not be more than 1.5 mm larger in diameter than the corresponding bolt diameter. The distance from the center of bolt holes to the edge of any steel section shall not be less than 1.5 times the diameter of the bolt.

All tower member joints or joints between prefabricated panels to be made at Site shall be secured with bolts, nuts and washers. As far as conveniently possible, bolt heads, rather than nuts, shall be on the outer or upper faces of support joints.

Structure cross arms shall be so arranged that they can be disconnected from the body without disturbing main structure body members.

The conductor landing points on cross-arms shall be so arranged that an additional hole for the attachment of conductor erection and maintenance tackle is provided adjacent to each hole for tension shackles. It shall be possible to apply full conductor tension and weight safely to these additional attachment points.

Mild steel when stored in the fabricators stockyard prior to fabrication and galvanizing shall be marked continuously throughout its length with a light blue water paint line. In addition the grade number of the steel shall be painted on and ringed around with paint.

Members that are capable of being fitted in more than one position on the structure shall all be of the grade of steel suitable for the most onerous loading conditions.

11.3.1 Step-bolts

Two diagonally opposite legs of all structures shall be equipped with galvanized step bolts (M16 x 160mm) on the leg at intervals not exceeding 380mm commencing immediately above the anti-climb device and extending to within one meter of earthwire. Step-bolt design shall be to the approval of the Employer or the Employer's Representative. Holes for removable step-bolts below the anti-climbing device shall be provided at not more than 380mm centers on the legs to which the permanent step-bolts are fitted.

11.3.2 Workmanship

All work shall be in accordance with the best modern practice in the manufacture and fabrication of materials covered by this specification. The Contractor shall be responsible for the correct fitting of all parts, shall replace free of cost any defective material discovered during erection and pay all



costs of field corrections for such replacement. All parts of the structure shall be neatly finished and free from kinks, twists or bends. All holes shall be made with sharp tools and shall be clean cut without torn or ragged edge. The fabrication shall be in strict accordance with the shop drawings prepared by the Contractor and approved by the Employer or the Employer's Representative.

Structural materials shall be straight and cleaned of all rust and dirt before laid out or worked in any manner. Shearing and cutting shall be performed carefully. Manually guided cutting torches shall not be used.

All bolt holes in steel members shall be punched, subpunched, reamed or drilled before galvanizing. Holes shall be drilled instead of being punched if the thickness of the metal exceeds the diameter of the hole. All holes shall be clean-cut and without torn or ragged edges. All holes shall be cylindrical and perpendicular to the member.

The diameter of the finished bolt hole shall not be greater than the normal diameter of the bolt plus 1.5mm. Plugging, welding or slotting of mispunched, misreamed or misdrilled holes will not be permitted. The holes shall be located accurately so that when the members are in position the holes will be lined up before being bolted.

11.3.3 Member fabrication-galvanising

All galvanising shall be carried out by the hot dip process and shall conform in all respects with BS 729.

All surface defects in the steel including cracks surface laminations, laps and folds shall be removed in accordance with BS 4360. All drilling, cutting, welding, forming and final, fabrications of unit members and assemblies shall be completed before the structures are galvanised. The surface of the steelwork to be galvanised shall be free from welding slag, paint, oil, grease and similar contaminants.

The preparation for galvanising and the galvanising itself shall not distort or adversely affect the mechanical properties of the material.

For all parts other than steel wires the coating shall consist of at least 610 grams of zinc per square meter of surface and be not less than 0.086mm in thickness.

On removal from the galvanising bath the resultant coating shall be smooth continuous free from gross surface imperfections such as bare, spits, lumps, blisters and inclusions of flux, ash or dross.

During off loading and erection of supports the use of nylon or braided slings shall be used. Galvanised steel work which is to be stored in the works or on site shall be stacked properly to provide adequate ventilation to all surfaces to avoid wet storage staining.

Small areas of the galvanised coating damaged in any way shall be restored in accordance with the requirements of item 1.7 of General technical specifications.

Tests on samples shall be carried out to BS 729.

11.3.4 Bolts and nuts

No bolt of diameter less than 16mm shall be used. No screwed threads shall form part of shearing plane between members.

When in position all bolts or screwed rods shall project through the corresponding nuts by at least one full thread but such projection shall not exceed 10mm.



Bolts shall be galvanised after thread cutting to the same specified coating weight as specified in BS 729.

Nuts and heads of all bolts shall be hexagonal.

All bolts, nuts and washers shall be hot dip galvanised and subsequently centrifuged (according to BS 729). Nuts shall be tapped after galvanising and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of the nut.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc rich paint. Only one type of bolt for the whole project, either mild steel or high tension steel will be permitted in order to prevent inadvertent misuse. The Contractor shall state clearly which type of bolt his designs are based upon.

All bolts supplied for this contract will be provided with one nut and one spring washer of approved design. Taper washers and packers are to be fitted where necessary.

The Contractor will instruct his supplier to select two samples of each type of bolt and nut to be used on the Contract and send these samples to the Employer or the Employer's Representative for approval within one month of the date of issuing the order. The Employer or the Employer's Representative will then reject bolt consignments, which in his opinion fall in any respect below the standard of samples submitted and approved.

11.4 TOWER EARTHING

In addition to the mechanical earthwire termination requirement, all steel towers shall be fitted with separate earth bonds for earthwire continuity and the Contractor shall provide all necessary connecting facilities.

The footing resistance shall be measured by the Contractor and approved by the Employer or the Employer's Representative for every tower prior to the stringing of the earthwire. The maximum footing resistance to the general mass of earth shall be 10 ohms.

Steel towers need not be fitted with a separate earth bond and earthing continuity throughout the support will therefore depend upon surface contact between members.

All towers shall be provided with means for connecting an additional earthing device as required by the Employer or the Employer's Representative. Holes are to be provided in all supports near ground level to take bolts for earth lead connections.

All legs of every tower shall be equipped with galvanized steel wire and cast into the foundation concrete to be readily available for the connection of additional earth electrodes in the event of the initial footing resistance exceeding 10 ohms. Tenderers rates for the structures shall include for such additional works.

Galvanized steel rods shall be driven where necessary in sufficient number to ensure the combined structure footing and earth electrode resistance does not exceed 10 ohms. Where it is necessary to drive more than one earth electrode at any support, the locations shall be to the approval of the Employer or the Employer's Representative. All earth electrodes shall be electrically bonded together using galvanized steel wire.

The tops of all electrodes shall be at least 500 mm below the surface of the normal reinstated ground level.



Connection of earth wires to the structure stub angles shall be by bolting. Tenderers shall submit details of his proposals in this regard.



CHAPTER 12:

MISCELLANEOUS ITEM FOR OVERHEAD LINE



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CHAPTER 12: Miscellaneous Item for Overhead line

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
12.1	Grounding Rods, Clamps and Conductor	1
12.1.1	Scope.....	1
12.1.2	Ground Rod	1
12.1.3	Ground Rod Clamp	1
12.1.4	Ground Wire	1
12.2	Other Requirements	2
12.2.1	Galvanizing	2
12.2.2	Applicable Standards	2
12.2.3	Tests	2



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12.1 GROUNDING RODS, CLAMPS AND CONDUCTOR

12.1.1 Scope

This Specification covers the fabrication and supply of galvanized steel ground rods, clamps and galvanized stranded steel grounding conductor for use in the neutral and body grounding for use in distribution transformers and overhead power line construction.

12.1.2 Ground Rod

The ground rod shall be made of high carbon, open-hearth steel so as to achieve maximum strength. It shall be hot dip galvanized. The ground rod shall be 19mm in diameter and 4,000 mm in overall length. The driven end of the ground rod shall have a truncated cone point. The cone point shall be approximately 13mm long, measured along the axis of the ground rod. The driving head of the ground rod shall have an approximate 3 mm, 45-degree chamfer. The manufacturing process shall assure that ground rod does not bend when driven into hard soils.

12.1.3 Ground Rod Clamp

The ground rod clamp shall be heavy duty forged steel clamp provided with a hex head cup point set screw of high strength steel with machine-cut threads. It shall be so manufactured that it gives low resistance connection. The ground rod clamp shall be galvanized. The clamp shall suitably accommodate and clamp a 19 mm. ground rod and a stranded grounding conductor.

12.1.4 Grounding Conductor

The conductor shall be 7-wire stranded conductor and shall conform to the characteristics as specified in Table contained herein. Stranded conductor shall be galvanized and PVC insulated (for low voltage).

The manufacturer of ground Conductor must have been accredited with ISO 9001:2000 with design and manufacturing quality certification.

The grounding conductor shall be galvanized after fabrication in accordance with IS: 2629-1985 or any revision thereof or any other national or international standards that ensure at least equal or better quality to the standard mentioned above will also be acceptable.

Se. No.	Description	Unit	Required rating/features
1	Diameter of Wire	SWG	7/12
2	Diameter of Single Strand	mm	2.67
3	Direction of Lay		Right
4	Weight	kg/km	299
5	Short time fusing current	kA	12
6	Resistivity	$\mu \Omega \text{cm}$	15

12.2 OTHER REQUIREMENTS

12.2.1 Galvanizing

The galvanization of ground rod, clamp and grounding conductor shall be in accordance with ISO 1461 or any revision thereof or other equivalent national or international standard provided that ensure at least equal or better quality to the standard mentioned above will also be acceptable. The minimum thickness of galvanization shall be 90 microns.

12.2.2 Applicable Standards

The equipment and components supplied shall be in accordance with the relevant IEC standards, or latest revision thereof or any other international standards and the NEA Specifications specified herein.

12.2.3 Tests

Grounds rods and clamps shall undergo type and routine tests in accordance with the relevant governing standards.

CHAPTER 13:
DATA COMMUNICATION SYSTEM AND SCADA/DMS



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CHAPTER 13: Data Communication System and SCADA/DMS

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
13.1	General	1
13.1.1	Scope of Works.....	1
13.1.2	Detailed Works.....	1
13.1.3	Other Requirements.....	2
13.1.4	Applicable Standards	2
13.1.5	Basic Requirements for Design	3
13.2	Outline of Data Communication System.....	4
13.2.1	Terminology	4
13.2.2	Overall Automation system for Distribution Line	4
13.2.3	Revenue Management System.....	5
13.2.4	Future Expansion Plans.....	5
13.2.5	Design Plan of Communication System.....	5
13.3	Data Communication Security	6
13.3.1	Adherence to Security Standards	6
13.3.2	Enhanced Access Control and Authentication	6
13.3.3	Data Communication Protection	6
13.3.4	Physical Security Measures.....	6
13.3.5	Regular Security Updates and Patches	6
13.3.6	Security Monitoring and Incident Response.....	6
13.3.7	Risk Assessment and Continuous Improvement.....	6
13.3.8	Network Segmentation and Protection.....	6
13.4	SCADA/DMS (Distribution Management System)	6
13.4.1	Workstation of SCADA/DMS.....	7
13.4.2	Software of SCADA/DMS	7
13.5	Testing of SCADA/DMS	8
13.5.1	Functional Performance Test of SCADA/DMS	8
13.5.2	Continuous Operation Test of SCADA/DMS	9
13.5.3	Field Tests (Site Acceptance Test, SAT).....	10
13.5.4	Field Installation Test	10
13.5.5	End-to-End Test	10
13.5.6	Field Performance Test	10
13.5.7	System Availability Test (360 hours)	11



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13.1 GENERAL

13.1.1 Scope of Works

The broad scope of the procurement of this part includes the survey, planning, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for:

- (a) SCADA/DMS (Local SCADA system)
- (b) MPLS-TP Equipment along with suitable optical line interfaces & tributary cards.
- (c) System integration of the supplied subsystems and integration with existing communication equipment such as SDH etc.
- (d) Integration of supplied system with the User's equipment such as FRTUs and the Central SCADA/DMS

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

SCADA/DMS (Local SCADA) at the substation shall be fully compatible with the Central SCADA/DMS system installed in the DCC in Kathmandu.

The Contractor shall also provide complete documentation, training and testing to fully support the hardware and software provided.

13.1.2 Detailed Works

Bidders are advised to conduct site surveys at their own expense before proposal submission. After contract award, the Contractor must perform necessary surveys at all sites, coordinating with the Employer.

(1) Submission of Survey Reports:

In the detailed design stage, the Contractor must submit a report for each site, including equipment layout, power supply confirmation, proposals for new buildings if needed, and identification of any additional items required for integration.

The report shall include at least the following items:

- (a) Proposed layout of Equipment in the planed rooms and buildings.
- (b) Proposed routing of power, earthing, signal cables and patch cords etc.
- (c) Proposals for new rooms/buildings if required
- (d) Identification of facility modifications if required

(2) Design and Environmental Considerations:

Design specific to each location, ensuring compliance with local environmental and earthing requirements.



(3) Integration of Communication Systems:

Integrate the procured communication equipment/subsystems with existing networks.

(4) Cabling and Wiring:

Perform all cabling and wiring work, including supply, installation, and termination, ensuring full connectivity and proper operation.

(5) Network Management Implementation:

Install and integrate network management software, hardware, and firmware as required.

13.1.3 Other Requirements

(1) General requirements

The Contractor shall manage the project, including periodic progress reports and review meetings during the contract period.

(2) Technical Supports

The Contractor shall provide engineering and technical assistance during both the contract and warranty periods.

(3) Quality Assurance

The Contractor shall provide Quality Assurance Plan allowing the Employer access to the manufacturing process.

(4) Testing

The Contractor shall submit the schedule and details procedures of the factory and site tests for the equipment. The tests shall include individual functional tests, characteristic tests, and integration tests between the equipment as SDH/MPLS, RTU, FRTUs

(5) Training

The Contractor shall offer training to the Employer's personnel.

(6) Spare Parts Availability

The Contractor shall ensure the availability of spare parts for the equipment's designed life or seven years after production cessation.

13.1.4 Applicable Standards

(1) General requirement

The equipment and works provided under this contract must comply with the following standards:

- IEEE 802.3
- ITU-T/CCITT Recommendations: G.652, G.701, G.702, G.703, G.711/12/14/35/36, G.721, G.742, G.811, G.823, G.801, G.821, G.822, G.823, G.826, V Series, R35, R37, R38A/R38B, M3010, G771.



- Internet Activities Board: RFC-1157 (SNMP).
- International Electrotechnical Commission (IEC) standards: IEC801-2/3/4/5, IEC-255-4, IEC-255-5, IEC-870-2-1, IEC-721-3-3, IEC-529, IEC 1000-4-xx series.
- IEC Publications: 68, 68-2-2, 68-2-3, 68-2-14, 68-2-27, 68-2-32.
- ITU-T/CCITT Recommendations: K.11, K.17, K.20.
- ISPR standards.

(2) Use of the Latest Versions

The specifications and codes must be the latest versions, including any revisions, that are in force at the time of the contract award. If new specifications, codes, or revisions are issued during the contract period, the Contractor should comply with them, provided no additional expenses are charged to the Employer without the Employer's written consent.

(3) Alternative Standards

If the Contractor proposes to supply materials or equipment according to any standard other than those listed here, they must include the full salient characteristics of the new standard for comparison in their proposal.

13.1.5 Basic Requirements for Design

(1) Encouragement of Standard Products

The Contractor is encouraged to use standard products but must provide any special equipment necessary to meet the requirements.

(2) Verification of Design Information

The design information and quantities specified in the document are indicative only. The Contractor must verify these through site surveys and detailed engineering and finalize the quantities as required for the final design and system performance.

(3) Information Requirements

Bidders must submit proposals that meet the functional and performance requirements of the specification, including sufficient information and supporting documentation to demonstrate compliance.

(4) Provision of Additional Items

If the design or site surveys reveal the need for additional items, the Contractor is responsible for providing these at no extra cost, ensuring a fully functional system that meets or exceeds the specified requirements.

(5) Interface with Existing Equipment

All equipment provided must be able to interface with existing equipment and support current and future requirements.

(6) Expandability



The communication equipment must be designed for expansion and reconfiguration without impairing normal operations.

13.2 OUTLINE OF DATA COMMUNICATION SYSTEM

13.2.1 Terminology

(1) Outgoing Feeder

The term "outgoing feeder" mentioned here refers to distribution lines installed at substations and distribution lines laid in the Pokhara area.

(2) Master Station

The Employer has a concept of monitoring and controlling distribution equipment from multiple remote locations.

These locations, which are positioned hierarchically above substations or distribution lines in terms of management, are referred to here as "Master Stations."

Specifically, Master Stations include the LDC (Load Dispatch Center) in Kathmandu, the DCC (Distribution Control Center) in Kathmandu, MCC (Master Control Center) in Kathmandu, the RDC (Regional Distribution Center) in the region, such as in Pokhara, and etc.

Unless otherwise specified, "Master Station" here refers to the DCC and RDC, with the RDC being a future concept.

(3) Local Station

For the convenience of explaining remote monitoring and control, substations are referred to as "Local Stations"

(4) Field Station

Facilities such as RMUs (Ring Main Units) installed on distribution lines are referred to as "Field Stations".

13.2.2 Overall Automation system for Distribution Line

To enhance automation and remote control of transmission and substation equipment, Substation Automation Systems (SAS) are being introduced. The Load Dispatch Center (LDCs) in Kathmandu are already operational, managing remote monitoring and control for transmission and substation equipment.

In this project, RTUs will be installed in substations, RTUs will implement interface functions for the remote monitoring and control of 11kV outgoing feeders (11kV cubicles) at substations by the Master Station and Local SCADA.

The overall monitoring and control of the substation equipment, along with remote interface functions from the Load Dispatch Center (LDC), and Distribution Control Center (DCC) will be handled by the substation's SAS (Substation Automation System).

Substation equipment, including 11kV circuits and distribution line switches, will be monitored and controlled by both the SAS in substations and the LDC/DCC. Monitoring data will be transmitted to the DCC via RTUs through the SAS gateway.



The DCC, having an overview function for the entire distribution network, is best positioned to control distribution line switches. For substation-side switches, such as those on the secondary side of transformers and busbars, control by the LDC and the SAS/substation is necessary to enhance operational efficiency.

RMUs will be installed on distribution lines, the inside CBs and LBS can be controlled remotely from DCC and Local SCADA, and transmit essential operational data to substation and DCC. The DCC will manage the control of distribution line switches such as RMU and G.O switches across the entire distribution network.

13.2.3 Revenue Management System

Separately, the Employer has been establishing DCUs (Data Concentrator Units) to collect energy data for customer service purposes, supporting the Revenue Management System (RMS) initiative.

The transmission power on the secondary side of the DT (distribution transformer) and the received power at the RMU will be transmitted to the DCU via GPRS (General Packet Radio System).

The energy data required by the DCU will be transmitted wirelessly at regular intervals.

13.2.4 Future Expansion Plans

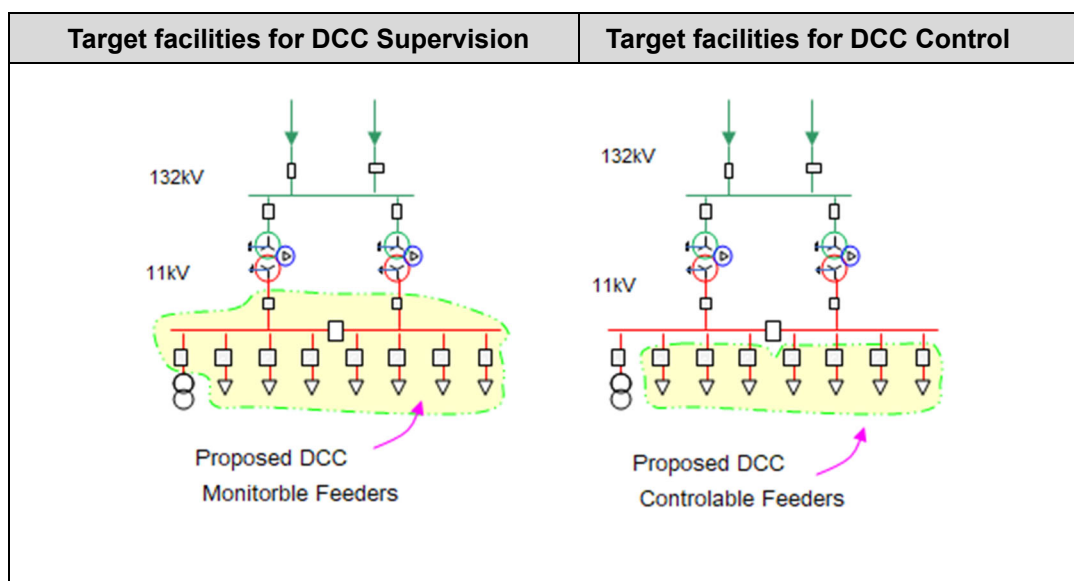
Plans are in place to establish RDCs and implement a Revenue Management System (RMS) to manage electricity sales. Additionally, higher-level centers such as a Master Operational Center (MOC) and a Security Operating Center (SOC) are also planned.

13.2.5 Design Plan of Communication System

The attached diagram outlines the data communication planned for the project.

Drawing Title	Drawing No.
Conceptual Diagram for Data Communication System	BIR-DL-4001

The range of 11kV equipment in the substation that the DCC will monitor and control is shown in the diagram below.



13.3 DATA COMMUNICATION SECURITY

To ensure a robust security system for RTU and SCADA, the followings should be performed.

13.3.1 Adherence to Security Standards

The system must comply with international security standards like ISO/IEC 27001 or NERC CIP, covering essential measures such as authentication, access control, encryption, monitoring, and logging.

13.3.2 Enhanced Access Control and Authentication

Implement multi-factor authentication (MFA) and strict access management, ensuring detailed logging of access, which should be regularly reviewed.

13.3.3 Data Communication Protection

Use TLS 1.2 or higher for encrypted communication between RTU and SCADA systems to prevent unauthorized access and data interception. Remote access should be secured through VPNs.

13.3.4 Physical Security Measures

Facilities housing RTU and SCADA systems must enforce physical access control and install surveillance cameras to prevent unauthorized physical access.

13.3.5 Regular Security Updates and Patches

The system provider must establish a process for timely security updates and patches, with regular reporting on the patch status.

13.3.6 Security Monitoring and Incident Response

The systems should include real-time security monitoring, automatic alerting on anomalies, and a prompt incident response based on predefined procedures.

13.3.7 Risk Assessment and Continuous Improvement

The provider should conduct regular security risk assessments and continually improve security measures based on the findings, with results and improvements reported to the client as needed.

13.3.8 Network Segmentation and Protection

The network between RTU and SCADA systems must be properly segmented with firewalls and DMZs to prevent unauthorized access from external networks.

13.4 SCADA/DMS (DISTRIBUTION MANAGEMENT SYSTEM)

In this project, the SCADA/DMS shall be installed in the substation building, and used for local data acquisition, monitoring and control of substation parameters and of equipment on distribution feeders through RTU. The SCADA/DMS shall be a Local SCADA system providing MMI capability for use in the substation control room building.

The SCADA/DMS (Local SCADA) system shall collect information remotely from DMS server installed in DCC in Kathmandu, and display or process it on Workstation installed in substation.



The Workstation at the substation functions as a client of the DMS server and retrieves information by sending request to the server. During this process, the Workstation to the server to obtain real time data and operational commands.

The Workstation at the substation shall has operational software installed to display information sent from the central DMS server.

The Workstation at the substation shall have local control capabilities to control and monitor equipment and parameters even in the event of a communication outage with a Central DMS server.

The DMS software at the substation periodically synchronize data with the Central DMS server. The Communication shall occur through Fiber Optical network.

The Workstation shall have redundant power supply, and it takes 220 Vac from UPS equipment to be installed in the construction work for the Substation portion. The cost for the UPS equipment shall be included in the BOQ for the substation portion.

13.4.1 Workstation of SCADA/DMS

The Workstation of SCADA/DMS shall has following functions, but the Contractor shall clarify the function required in the site survey, and shall take responsibility for the performance of SCADA/DMS system in the substation.

- (a) High-Performance Processor: A multi-core CPU (Intel Core i7/9 or Xeon)
- (b) Sufficient Memory: more than 16 GB of RAM (32 GB or more recommended)
- (c) Storage: SSD with a minimum capacity of 512 GB (1TG or more recommended)
- (d) High-Resolution Display: Support Full HD or higher resolution
- (e) Environmental Durability: Designed to withstand substation environments
- (f) Dual Power supply:
- (g) RAID configuration: support for RAID (RAID 1 or RAID 5) for data protection and fault tolerance

13.4.2 Software of SCADA/DMS

The SCADA/DMS software at the substation shall include following basic functions, but the Contractor shall clarify the function required in the site survey, and shall take responsibility for the compatibility with the Central SCADA/DMS system and performance of SCADA/DMS system in the substation.

- (a) Stable and Compatible OS: it shall totally meet requirements and shall be compatible for the Central SCADA/DMS system installed in DCC
- (b) Security Update:
- (c) Local SCADA system: monitor and control substation equipment and equipment on the distribution feeders
- (d) Schematic/Geographical View: Geographical network views and outage details for efficient operation of the distribution network
- (e) GIS adaptor:



- (f) Topology Processor Function: Energization of lines, transformers, bus sections, ON/OFF status of switchgears and load break switches
- (g) Real Data Processing: Process status change of a status point which happen in quick succession (within 1 second)
- (h) Outage Management System (OMS):
- (i) Fault Management and System Restoration (FMST) Application:
- (j) Alarm: Un-command changes in state of telemetered and calculated digital input
- (k) Data Synchronization: Ensures real-time data synchronization with the central DMS server
- (l) Data analysis: localized load analysis and basic fault detection
- (m) Authentication and Encryption: Secure communication via VPN and multi-factor authentication (MFA) and access control for user security
- (n) Log Management: Records detailed even and operation logs
- (o) Data Recovery:
- (p) Local Data Storage and Retrieval: For temporary data storage

The Contractor shall supply separate license for each copy of SCADA/DMS software.

13.5 TESTING OF SCADA/DMS

13.5.1 Functional Performance Test of SCADA/DMS

The functional performance test shall verify all features of the SCADA/DMS hardware and software. As a minimum, the following tests shall be included in the functional performance test:

- (a) Testing of the proper functioning of all SCADA/DMS & other software application software' s in line with the requirements of various sections of technical specification.
- (b) Simulation of field inputs (through RTU/FPI) from test panels that allow sample inputs to be varied over the entire input range
- (c) Simulation of field input error and failure conditions
- (d) Simulation of all type of sample control outputs
- (e) Verification of RTU /FPI communication Protocol IEC60870-5-104 /101 etc
- (f) Verification of MFT communication Protocol MODBUS etc
- (g) Verification of compliance of supporting interfaces such as IEC61850, IEC60870-5-103 etc.
- (h) Verification of CIM compliance
- (i) Verification of Security & Encryption using SSL for all RTU/FPI connectivity
- (j) Verification of Data Integration from SCADA/DMS system other systems viz IT Systems etc over Open Standards over CIM/XML, IEC 61968 Series Standards, OPC, ICCP etc.,



- (k) Verification of Integration between GIS / SCADA/DMS System over OAG, CIM/XML or tight Native Integration, that enables updates within GIS to percolate over ESB / SOA to IT Systems
- (l) Verification of data exchange with other systems
- (m) Verification of interoperability profile of all profiles of all protocols being used.
- (n) Verification of RTU /FPI communication interfaces
- (o) Verification of LAN and WAN interfaces with other computer systems
- (p) Testing of all user interface functions, including random tests to verify correct database linkages
- (q) Simulation of hardware failures and input power failures to verify the reaction of the system to processor and device failure
- (r) Demonstration of all features of the database, display, and report generation and all other software maintenance features on both the primary and backup servers. Online database editing shall also be tested on primary server.
- (s) Demonstration of the software utilities, libraries, and development tools.
- (t) Verification that the SCADA/DMS computer system meets or exceeds employer's performance requirements (as per table for peak & normal loading in section 8 Verification of Design parameters as mentioned in section 8 & wherever defined in the specification.
- (u) Verification that ultimate expansion requirements are met.
- (v) Verification of DTS (Dispatcher Training Simulator)
- (w) Verification of Development system
- (x) Verification of data transfer of main to back up SCADA/DMS system.
- (y) Functions of DR (Disaster Recovery) system.
- (z) Unstructured testing of the SCADA/DMS system by employer. The unstructured tests shall include the test, which are not in the approved test procedures and may be required to verify the compliance to the specification. (Max 20% of total testing)

13.5.2 Continuous Operation Test of SCADA/DMS

This test shall verify the stability of the SCADA/DMS hardware and software after the functional performance test has been successfully completed. During the test, all SCADA/DMS functions shall run concurrently, and all Contractor supplied equipment shall operate for a continuous 48 (forty-eight) hour period with simulated exchange with other interconnected system viz. various IT system etc. The test procedure shall include periodic repetitions of the normal and peak loading scenarios defined. These activities to be tested may include, but shall not be limited to, database, display, and report modifications, configuration changes (including user commanded processor and device failover), switching off a primary server and the execution of any function described in this Specification. During the tests, uncommanded functional restarts or server/device failovers are not allowed; in case the problems are observed, the Contractor shall rectify the problem and repeat the test.



13.5.3 Field Tests (Site Acceptance Test, SAT)

The SCADA/DMS system shall be tested at the site. All hardware and software associated with the SCADA/DMS system along with all RTUs/FPIs etc. along with all field devices including MFTs connected shall be tested under the field tests.

13.5.4 Field Installation Test

The equipment which has undergone the factory testing shall be installed at site and integrated with the RTUs / FPI and other computer systems through the communication medium.

- (a) Proper installation of all delivered hardware as per approved layout.
- (b) Interconnection of all hardware
- (c) Interconnection with communication equipment's
- (d) Interconnection with power supply
- (e) Diagnostic tests to verify the operation of all hardware
- (f) Random checking of SCADA/DMS software basic functions

The Contractor shall be responsible for performing the field installation tests and Employer may witness these tests.

13.5.5 End-to-End Test

After the field installation tests, the Contractor shall carry out end-to-end test to verify:

- (a) the communication of RTUs /FPIs/MFTs with SCADA/DMS system
- (b) the RTU / FPI communication channel monitoring in the SCADA/DMS system
- (c) the mapping of SCADA database with RTU / FPI database for all RTU/FPI points
- (d) the mapping of SCADA database with displays and reports

The Contractor shall provide the details of all the variances observed and corrections carried out during End-to-End Test.

13.5.6 Field Performance Test

The field performance test shall concentrate on areas of SCADA/DMS operations that were simulated or only partially tested in the factory (e.g., system timing and loading while communicating with a full complement of RTUs/ FPI and data links and system reaction to actual field measurements and field conditions). Further the validity of factory test results determined by calculation or extrapolation shall be examined.

After the End-to-End test, the Contractor shall conduct the field performance test to verify the functional performance of the system in line with the technical specification which includes the following:

- (a) the communication of other systems i.e IT, SLDC, DR system with SCADA/DMS system
- (b) Mapping of SCADA/ISR database with other system database viz IT, SLDC, DR system.



- (c) Verify that all the variances observed during the Factory test are fixed and implemented.
- (d) Conduction of the Factory tests deferred (tests requiring site environment)
- (e) Functional tests of SCADA/DMS system
- (f) Verify the execution rates of all SCADA/DMS application
- (g) Verify update rate & time for data update & control command execution as per specification requirements
- (h) Verify the response time of all SCADA/DMS applications.
- (i) Verify the response time for User interface requirements
- (j) Testing of all features of the database, display, and report generation and all other software maintenance features on both the primary and backup servers. Online database editing shall also be tested on primary server.
- (k) Conduction of unstructured tests as decided by the Employer

13.5.7 System Availability Test (360 hours)

Contractor shall provide & approve theoretical and practical figures used for this calculation at the time of detailed engineering. The calculation shall entail reliability of each individual unit of the System in terms of Mean Time Between Failures (MTBF and a Mean time to Repair (MTTR) as stated by OEM. Reliability figures of existing equipment shall be supported by evidence from operational experience at similar types of installation / figure given by OEM.

From those data, the unavailability of each sub-system shall be calculated taking in account each item redundancy. The global availability shall then be calculated from those different unavailability data. This calculation shall lead to the failure probability and equivalent global MTBF data for the control center system.

The overall assessment of System availability shall be provided in the form of an overall System block diagram with each main item shown, complete with its reliability data. The calculation of overall availability shall be provided with this diagram.

System availability tests shall be conducted after completion of the field tests. The system availability test shall apply to the SCADA/DMS system (hardware and software) integrated with its RTUs/ FPIs and IT SYSTEM.

However, the non-availability of RTUs/Data Concentrators/ FPI, IT system etc & Communication System shall not be considered for calculating system availability. However, RTU, communication equipment's, Auxiliary power supply shall be tested as per the provisions given in their chapters.

The SCADA/DMS system (hardware and software systems) shall be available for 99.5% of the time during the 360hours (15 days) test period. However, there shall not be any outage /down time during last 85 Hours of the test duration. In case the system availability falls short of 99.5%, the Contractor shall be allowed to repeat the system availability test after fixing the problem, failing which the system shall be upgraded by the Contractor to meet the availability criteria without any additional cost implication to the owner.

Availability tests of RTUs shall be conducted along with System availability test for 360 hours. Each RTU shall exhibit minimum availability of 98%. In case the RTU availability falls short of 98%, the



Contractor shall be allowed to repeat the RTU availability test (for failed RTU only) after fixing the problem, failing which the equipment shall be upgraded by the Contractor to meet the availability criteria without any additional cost implication to the owner.

In the event of unsuccessful reruns of the availability test, employer may invoke the default provisions described in the General Conditions of Contract. The system availability tests will be performed by the owner by using the SCADA/DMS system and RTUs/ FPI for operation, control and monitoring of distribution system and using Contractor supplied documentation. The owner will also be required to generate daily, weekly and monthly reports. The supplied system shall be operated round the clock.

The SCADA/DMS system shall be considered as available if

- (a) one of the redundant hardware is available so that all the SCADA/DMS applications are functional to ensure the design & performance requirement as envisaged in the specification
- (b) at least one of the operator console is available
- (c) at least one of the printers is available (off-lining of printers for change of ribbon, cartridge, loading of paper, paper jam shall not be considered as downtime)
- (d) All SCADA applications are available
- (e) All DMS applications are available
- (f) All SCADA/DMS functions described in the specification are executed at periodicities specified in the specification. without degradation in the response times
- (g) Requests from available Operator Consoles & VPS are processed
- (h) Information Storage and Retrieval applications are available
- (i) Data exchange with other system is available

However, each device, including servers, shall individually exhibit a minimum availability of 98%. The nonavailability of following Non-Critical functions shall not be considered for calculations of system availability; however, these functions should be available for 98% of the time.

- (j) Database modification and generation
- (k) Display modification and generation
- (l) Report modification and creation
- (m) DTS (Dispatcher Training Simulator)

During the availability test period, employer reserves the right to modify the databases, displays, reports, and application software. Such modifications will be described to the Contractor at least 48 hours in advance of implementation to allow their impact on the availability test to be assessed, except where such changes are necessary to maintain control of the power system.

The successful completion of system availability test at site shall be considered as “operational acceptance” of the system.



CHAPTER 14:
NETWORK CONFIGURATION AND EQUIPMENT



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CHAPTER 14: Network Configuration and Equipment

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
14.1	Introduction	1
14.2	General Network Characteristics.....	1
14.2.1	Description.....	1
14.2.2	Functional Requirement.....	1
14.2.3	General Systems Requirements	2
14.3	Equipment Details: MPLS-TP System	3
14.3.1	Functional Requirements	3
14.3.2	Equipment Requirements	3
14.3.3	Technical Specification.....	4
14.3.4	Management.....	11
14.4	Optical Link Performance Requirements.....	11
14.4.1	Link Budget Calculations	11
14.4.2	Link Performance.....	11
14.5	FODP to MPLS-Equipment.....	12
14.6	Patch Cords.....	12
14.7	Telecommunication Management Network / Network Management System	12
14.7.1	Applicable Standards	13
14.7.2	General Operational and Functional Requirements	13
14.8	Management Functions	14
14.8.1	Configuration Management.....	14
14.8.2	Fault Management.....	15
14.8.3	Performance Management	16
14.8.4	Security Management	17
14.8.5	Inventory Management	18
14.8.6	Software Management.....	18



14.9	Communication Channel Requirement and Integration	19
14.10	Craft Terminal.....	19
14.11	Hardware Requirements.....	20
14.11.1	Server, Workstation and Craft Terminal	20
14.11.2	Local / Remote Operator Consoles.....	21
14.11.3	Power Supplies	21
14.12	General Software/Firmware Requirements.....	21
14.12.1	Operating System Software	22
14.12.2	Application Software	22
14.12.3	Software Utilities	22
14.12.4	Revisions, Upgrades, Maintainability	22
14.12.5	Database(s)	22
14.12.6	Help	22



14.1 INTRODUCTION

This section describes the Fibre 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:

- (a) Fibre Optic Transmission System (FOTS)
- (b) Telecommunication Management Network (TMN) / Network Management System (NMS)
- (c) Craft Terminal based Telecommunication Management Network /Network Management System

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 equipment 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 from an authorized and certified agency/lab.

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, equipment, 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 of Nepal.

14.2 GENERAL NETWORK CHARACTERISTICS

14.2.1 Description

The fibre optic network shall be based on the MPLS-TP having bit rate of 1 G (up to 5 directions) and 1G (up to 4 directions). The network shall consist of overhead and underground fibre optic links with a minimum bit rate of 1 G.

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.

14.2.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for operation in support of the SCADA/RTUs/FRTUs. The communications support requirement for SCADA/RTUs/FRTUs system is for low & high-speed data, express voice circuits and administrative voice circuits as defined in appendices. The FRTUs located at various locations will report to Control Centre using IEC 60870-5-104 Protocol. The proposed



communication system shall provide connectivity of RTUs over TCP/IP protocol using Ethernet interface and few other RTUs over serial interface. The offered communication System shall support the communication requirements of RTUs and the SCADA/DMS system described in point to multi point and/or multipoint to multipoint configurations using MPLS-TP

The fibre optic network shall be based on the MPLS-TP having bit rate of 1 G. The network shall consist of overhead fibre optic links with a minimum bit rate of 1 G. 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.

A brief summary of the communication system requirements is as follows:

- (a) Data transport supporting Network Management channels
- (b) The connectivity envisaged between FRTUs and Control Centre over MPLS-TP.

14.2.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

(1) 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.

(2) 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.

(3) Equipment Availability

The calculated availability of each fibre optic link shall be at least 99.99%. 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.

(4) Revision Level 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.

(5) 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

14.3 EQUIPMENT DETAILS: MPLS-TP SYSTEM

The product with low footprint & power efficient shall be offered for the access/ distribution layer in intra-city. The system shall support circuit emulation. MPLS-TP (MPLS-Transport Profile) Equipment shall provide the following:

- (a) OAM functions to detect and isolate faults (Like SDH/ SONET)
- (b) Sub-50ms protection and restoration
- (c) Ring & mesh architecture.
- (d) End-to-end QoS

14.3.1 Functional Requirements

The offered MPLS-TP platform must be a reliable packet-based network based upon circuit-based transport networking. The architecture of the MPLS-TP platform must be defined as per the IETF RFC 5921& 6215. The requirements for MPLS-TP forwarding, OAM, and network survivability must be in compliance with RFC 5654 and 5860.

The switching fabric plane shall be bidirectional and nonblocking.

The Equipment's shall support a wire speed L2 switching capabilities under full load condition. The platform shall support enterprise services like Ethernet E-Line & E-LAN services and aggregate & hand over the traffic to next higher Metro Ethernet network Core Layer.

The management of the MPLS-TP networks must be separable from its client networks so that the same means of management can be used regardless of the client. The management functions of MPLS-TP must include fault management, configuration management, performance monitoring, and security management.

The purpose of the management function must be to provide control and monitoring of the MPLS transport profile protocol mechanisms and procedures. The requirements for the network management functionality must be as per RFC5950 & RFC5951.

MPLS-TP platform must mandatorily run BFD (Bidirectional Forwarding Detection) protocol to provide OAM functionality. It should have resiliency to ensure minimal interruption to traffic when a failure occurs within the system or network.

14.3.2 Equipment Requirements

- (a) The size of equipment shall not exceed 2RU in size.
- (b) Equipment sub rack must be suitable to install in 19 inch / 21 inch rack
- (c) The supplier shall confirm that their solution supports insert, replace and remove of modules while the equipment is powered up without affecting traffic and damaging any module.
- (d) All NEs and cards provided by supplier must be managed on the NMS.



Se. No.	Particular	Type-1	Type-2
1	Maximum Size (in RU)	2RU	1RU
2	Ports (Min)	10x1G (Optical) + 8x1G (Electrical)	8x1G (Optical) + 4x1G (Electrical)
3	Bi-Directional SFP/XFP	Yes	Yes
4	Redundancy (Power supply and Cross connect/Switch card)	Yes (Both PSU & Cross Connect)	Only Power Supply
5	Chassis	Modular	Any Type
6	Power (Input Voltage)	-48V DC	-48V DC / -220V AC

14.3.3 Technical Specification

(1) Standard Requirements

All equipment must comply with the Generic requirements for MPLS-TP based carrier Ethernet switch for Aggregation & Access Network Applications. A statement of compliance shall be submitted along with the Bid

The switching fabric plane shall be bidirectional and non-blocking. The equipment shall support a wire speed L2 switching capabilities under full load condition.

The Equipment shall support Ethernet PW as specified by RFC 3985 and RFC 4385. It shall support Ethernet PW as specified by RFC 4448.

The MPLS-TP Equipment has UNI (User Network Interface) and NNI (Network Node Interfaces). The MPLS-TP Equipment shall support UNI or NNI mode of operation on all the ports.

Optical Ethernet interfaces shall be configured as Client or Aggregate interfaces based on requirement.

All Equipment shall support jumbo frame of 9000 bytes, MDI-X based auto-uplink feature & dynamic online configuration.

The Equipment shall support buffering of 50ms to take care of momentary congestion and link failures.

The equipment shall support IPv4 and IPv6 traffic transparently at data plane.

All Equipment shall be able to function in terminal mode, hub, & mesh and ring topologies.

The equipment shall provide managed multi-service integration viz., voice, video and data.

All equipment shall be fully compliant to MEF 9, MEF 14 or CE2.0 standards.

It shall support built in power diagnostics feature to monitor optical SFP/XFP ports, system diagnostics to detect hardware failures.

(2) Layer-2 Switching Features

It shall support ingress and egress bandwidth profile per User to Network Interface (UNI).

Equipment shall support Ethernet functions VLAN (IEEE 802.1Q), Q-in-Q (IEEE 802.1ad), VLAN manipulation: stack/switch/strip, Flow control (IEEE 802.3x), IGMP snooping (V1/V2/V3), Link aggregation (IEEE 802.3ad).



Equipment shall support Link Layer Discovery Protocol as per IEEE 802.1ab, Logical Link control as per IEEE 802.2&Flow control as per IEEE 802.3x.

The equipment shall support enterprise services like Ethernet E-Line & E-LAN services and aggregate the traffic and hand over the same to the next higher Metro Ethernet network Core Layer.

Service multiplexing: A single MPLS-TP Equipment port shall support multiple Ethernet Services

(3) VLAN Features

The MPLS-TP Equipment shall support creation of VLAN among ports of different types as well as on all ports of the interface cards.

It shall support VLAN bridging (for outer tag only) as per IEEE 802.1ad and user isolation per outer VLAN tag.

The user isolation shall be configurable on a per port basis.

The MPLS-TP Equipment shall support VLAN ingress filtering to prevent VLAN leakage & VLAN tag overlapping allowing some ports to be member of more than one VLAN.

(4) Port Trucking / Link Aggregation

The MPLS-TP Equipment shall allow Link Aggregation as per IEEE 802.3 ad to allow link resilience.

Supports load balancing over Aggregated Links.

Static/LACP LAG on client ports shall be configured in all equipment.

(5) Forwarding Support

The MPLS-TP Equipment shall support to override the MPLS-TP Equipment port MAC address.

It shall also support VPLS instance static MAC configuration.

(6) MAC Address Learning / Limiting:

The MPLS-TP Equipment shall support L2 Learning parameters: Sources learning per Port/VPLS/VLAN/Source address.

The MPLS-TP Equipment shall support to set per port/VPLS instance dynamic MAC learning limit.

The MPLS-TP Equipment shall support to limit the number of source MAC addresses learnt from bridge port/VPLS instance in order to prevent MAC address flooding DoS attack. This limit is configurable per bridged port.

The MPLS-TP Equipment shall support dropping of Frames with new source MAC-addresses exceeding the configured value.

The MPLS-TP Equipment shall support per VLAN MAC learning to ensure MAC addresses are learnt only from a VLAN perspective and automatic/manual disabling of MAC addresses learning for the VLAN where there are less than two ports in that VLAN.

The MPLS-TP Equipment shall support MAC limiting per Ethernet flow point (EFP) or bridge domain

The MPLS-TP Equipment shall support MAC address limitation and aging

All static entries shall NOT be aged.



The MPLS-TP Equipment shall support Hardware based aging of MAC Address Table entries.

The MPLS-TP Equipment shall support to enable L2 Aging on every port

The MPLS-TP Equipment shall support MAC address learning disabling

The MPLS-TP Equipment shall support to filter and discard all Ethernet frames received on bridged ports in the upstream direction with a specific MAC destination address (DA)

The MPLS-TP Equipment shall support list of allowable MAC destination address

The MPLS-TP Equipment shall filter the MAC address from bridge port X if the same MAC address appears in the learning table pointing to bridge port Y (port X and port Y on the same the MPLS-TP Equipment and same VLAN), except in the cases where the aggregation network forwards according to MAC Learning table.

The MPLS-TP Equipment shall support unique MAC address per device to prevent spoofing and provide traceability.

The MPLS-TP Equipment shall have the capability to prioritize BPDUs in the data plane (by providing dedicated queues) and in the control plane (by providing dedicated CPU queues for BPDUs).

The MPLS-TP Equipment shall have the capability to drop BPDUs regardless of the BPDU content. This function is configurable on a per port basis.

(7) The MPLS-TP Equipment shall support IEEE 802.1Q Tagging

Tagged only, this is an IEEE 802.1Q trunk.

Untagged.

Hybrid, tagged and untagged frames.

The MPLS-TP equipment shall support the following additional IEEE 802.1Q features

Tag insertion, removal and swapping.

Capability of insertion and removal of second tag.

Encapsulation translation and rewrites Push, Pop and translate for IEEE 802.1Q or QinQ/IEEE 802.1ad tags.

Local VLAN and ports cross-connect and multipoint or point-to-multipoint with Hierarchical Virtual Private LAN service (H-VPLS bridge topologies with pseudo-wires) or locally defined bridge domains.

The MPLS-TP Equipment shall accept untagged, priority tagged and C-tagged frames through a IEEE 802.1Q port.

(8) Q-in-Q or IEEE 802.1ad mode Requirements

The MPLS-TP Equipment's shall perform classification and service delineation based on outer Q tag and outer IEEE 802.1p bits. (i.e. ignore inner tag)

(a) It shall support VLAN stacking as per IEEE 802.1ad



- (b) It shall have minimum of 4094 S-VIDs.VIDs "0" and "FFFF" is reserved.
- (c) It shall allow only S-tagged frame in '.1ad' ingress ports. It shall be possible to map the traffic to any PW based on SVLAN tag. It shall be possible to keep or pop the SVLAN tag before forwarding it to the PW.
- (d) It shall be possible to set the priority bits in the S-VLAN priority based on the PCP bits of C-tag of the incoming packet in '.1ad' mode.

(9) LSP Mode Requirements

The MPLS-TP Equipment shall support LSP Mode Scalability Options i.e. Virtual Private LAN Service (VPLS)

- (a) Support Packet Transport Network solution using PW service tunnel.
- (b) TDM and Ethernet traffic shall be emulated into Pseudo-wires and PW label is added for service identification.
- (c) End-to-end transport path LSP shall be created based on MPLS-TP standard and multiple
- (d) The traffic tunnels shall support per LSP queuing/scheduling i.e. the ability to assign and guarantee per LSP per class bandwidth profiles (CIR, EIR, CBS, and EBS)

(10) Quality of Service Requirements

The MPLS-TP Equipment shall support VLAN CoS preservation.

The MPLS-TP Equipment shall support VLAN CoS differentiation: It shall be possible to configure the classification of the traffic according to the port, VLAN, IEEE 802.1p bits or TOS/DSCP bits.

The MPLS-TP Equipment shall support creation of VLAN or Flow with DSCP parameters per service for data, video and O&M traffic for service differentiation.

It shall support measurement of performance bounds for each flow in terms of throughput, loss, delay and delay variation, according to their respective defined service classes as per Y.1731.

The MPLS-TP Equipment shall support 16, 32, 64,128,256 and 512 k bytes burst sizes.

The MPLS-TP Equipment shall support wire speed forwarding on all interfaces and all packet sizes even with classification and QoS activated on all interfaces.

The MPLS-TP Equipment shall support bandwidth management reports and statistics.

The Edge the MPLS-TP Equipment shall support 8 class of service per flow.

(11) Classification/Prioritization:

The MPLS-TP Equipment shall support classification of ingress traffic for a specific service based on the following mapping:

- (a) IEEE 802.1P Mapping - it shall be possible to reserve parts of the link bandwidth for frames with particular IEEE 802.1p values.
- (b) Customer IEEE 802.1p priority
- (c) Multiprotocol Label Switching (MPLS) Label Stack Entry:"EXP" Field Renamed to "Traffic



Class" Field as per RFC 5462

- (d) Source MAC address
- (e) Destination MAC address
- (f) VLAN ID
- (g) IEEE 802.1Q
- (h) Default queue for non-matching traffic

The MPLS-TP Equipment shall aggregate incoming traffic into Traffic Classes by following characteristics:

- (i) Incoming port (Logical and Physical)
- (j) Source/ destination MAC
- (k) Link layer priority information as per IEEE 802.1p

(12) Mapping

The MPLS-TP Equipment shall support mapping of DSCP/VLAN/Port to MPLS labels.

Mapping of IEEE 802.1p and IP TOS bits into MPLS EXP bits.

Mapping of IEEE 802.1q VLAN tags into MPLS labels

Aggregate incoming traffic into Traffic Classes by MPLS Label EXP bits (E-LSP)

(13) Marking/Policing/Shaping:

The MPLS-TP Equipment shall support the following Marking/Policing/Shaping requirements

- (a) 8 level Priority marking as per IEEE 802.1p
- (b) Filtering
- (c) Broadcast/Multicast suppression
- (d) Bandwidth management policies
- (e) Single rate three colour marking (srTCM)
- (f) Two rate three colour metering (trTCM)
- (g) Trust the colour of the incoming packet.
- (h) Differentiated Service Two-Rate, Three-Color Marker with Efficient Handling of in-Profile Traffic
- (i) Shaping of Burst Traffic

(14) Rate Limiting

The Equipment shall support Rate limiting of bandwidth per Port and per class (or flow)

Configuration of user bandwidth shall be supported, in steps of

- (a) Mbps for 1-1000Mbps



- (b) 100 Mbps granularity for 1-100 Gbps

It shall support defining Committed Information Rate (CIR) and an Excess Information Rate (EIR) for each flow in steps of 1Mbps

The MPLS-TP Equipment shall support flow-based rate limiting method based on per source address, destination address or both.

(15) Queuing:

The MPLS-TP Equipment shall support the following queuing

- (a) SPQ – Strict Priority Queuing
- (b) WFQ – Weighted fair Queuing
- (c) No of queues per flow treatment of traffic.
- (d) Per service ingress queues are defined on the basis of Peak/Excess burst Size (PBS/EBS), Committed Burst Size (CBS), Peak/Excess Information Rate (PIR/EIR) and committed Information rate (CIR).
- (e) Per service egress queues have distinct parameters defining its operations like Peak/Excess burst Size (PBS/EBS), Committed Burst Size (CBS), Peak/Excess Information Rate (PIR/EIR) and committed Information rate (CIR).
- (f) Alternate priority routing traffic necessary to keep from starving other priority queues.

(16) Scheduling

The MPLS-TP Equipment shall support scheduling of queues to strict priority with 2 or more priority levels

The MPLS-TP Equipment's shall support the following congestion avoidance mechanisms

- (a) Tail Drop
- (b) Deficit Round Robin (DRR)
- (c) Weighted Round Robin (WRR)
- (d) DWRR (Deficit Weighted Round Robin)
- (e) WRED
- (f) Strict Priority (SP)
- (g) SP + Weighted Round Robin (SP + WRR)

The MPLS-TP Equipment shall support configuring the scheduling as per the

- (h) Per Hop Behaviour (PHB)
- (i) Physical port or logical port basis.
- (j) Up to 8 forwarding class queues can be configured on a per service basis each with its own CIR, PIR, CBS, PBS and Forwarding Class attribute.



(k) At least three level dropping precedence levels in each queue.

(17) Protection Mechanism:

The MPLS-TP Equipment shall support linear protection (1:1 & 1+1) as specified in ITU-T Rec. G.8131.1 or G.8131.2.

For all the modes of protection, The MPLS-TP Equipment shall support protection switching within 50ms of expiration of any manually selected hold-off time (with both SF/SD scenario) and shall support all operator commands (Forced Switching [FS], manual Switching [MS], lockout of protection).

The MPLS-TP Equipment shall support protection switching within 50ms and Forced switching as analogous to SDH systems.

The MPLS-TP Equipment shall support protection switching triggered by fault detection, such as loss of signal, loss of frame, signal degrade (BER becomes worse than the predetermined threshold), and so on.

The MPLS-TP Equipment shall support Forced switching activated by administrative events, such as fibre rerouting, fibre replacement, etc.

The MPLS-TP Equipment shall support Ethernet ring protection for both S-VID and B-VID as per G.8032

The MPLS-TP Equipment shall support MPLS-TP Linear Protection support as per IETF standards or Ethernet/MPLS SNC based protection as per ITU-T standards.

(18) Circuit Emulation Protocols

The MPLS-TP Equipment shall support PW using Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP) or MEF8.

The equipment shall support E1/channelized STM-1 circuit emulation mechanism and it shall support Circuit Emulation Services over MPLS as per PWE3 standard to aggregate the TDM PW from the edge and access CEN.

(19) Network Synchronization Requirements

The MPLS-TP Equipment shall be able to synchronize with an external reference clock.

It also support Synchronous clock selection algorithm based on the following parameters:

- (a) Quality of Signal
- (b) Signal fail
- (c) Priority
- (d) External Commands

It shall support SyncE as per ITU-T G.8261, G.6282 and G.8264 or IEEE 1588v2.

- (e) The MPLS-TP Equipment shall support Network Time Protocol (NTP) for synchronizing with a central NTP server.

The MPLS-TP Equipment shall support timing and synchronization aspects of Packet Networks



based on SyncE as per G.8261. The MPLS-TP Equipment shall support timing characteristics of a synchronization slave clock as per G.8262.

The MPLS-TP Equipment shall support provide a timing-output interface at 2048 kHz for external synchronization. The output shall conform to ITU-T Rec. G.812, as applicable.

14.3.4 Management

The MPLS-TP system shall support the In-Band & Out-Band management communication channel. The management function of MPLS-TP includes fault management, configuration management, performance monitoring, and security management. The management function must provide control and monitoring of the MPLS transport profile protocol mechanisms and procedures.

The requirements for the network management functionality must be as per RFC5951.

14.4 OPTICAL LINK PERFORMANCE REQUIREMENTS

The optical fibre link performance requirements are specified as follows.

14.4.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

- (a) Fibre attenuation: The actual attenuation figure (including fibre, splice, connector loss) shall be provided during detailed engineering for link budgeting of backbone/ access links.
- (b) 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 offered equipment, an End of Life Margin of at least 2 dB shall be considered. This parameter is to be considered for all links.
- (c) Optical path Penalty: An optical path penalty of at least 1 dB (or bidder's standard design value whichever is higher) shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp. This parameter is to be considered for all links.
- (d) Maintenance Margin: Appropriate maintenance margin shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc during planning & execution.
- (e) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered for all links.
- (f) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.km (1550 nm) for G.652 fibre.
- (g) Link solution shall be offered considering the parameters defined above.

14.4.2 Link Performance

The Link performance for ES, SES and BBER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826, G.828, M.2101, RFC 2544 and Y.1564.



14.5 FODP TO MPLS-EQUIPMENT

The Contractor shall be responsible for connectivity between the FODP and the MPLS-TP 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.

14.6 PATCH CORDS

The Contractor has to supply FC PC coupled Patch cords. 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. The Contractor shall provide (i.e. supply and install) connectorised FODP-to-equipment and equipment-to-equipment jumpers (patch-cords) for each equipment with two installed spares.

The Contractor shall be required to provide armoured patch-cords at some of the locations prone to rat cuts. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose. Contractor shall provide patch cords of appropriate length for interconnection amongst equipment ports and with FODP for proper routing inside the cabinet and to maintain aesthetics. Contractor shall assess the requirement of various lengths of patch cords during survey and keep sufficient quantity of various length of patch cords to cater any changes during Installation. The Patch cords shall comply with the following:

- (a) All the patch cords shall be Single Mode (G657A Fiber), Simplex type. The aramid yarn used in the cable of the patch cord shall be genuine and not plastic based.
- (b) Maximum insertion loss for a patch cord should $<0.2\text{dB}$ @ 1310 & 1550nm wavelengths.
- (c) All the patch cords/Connector End face should meet cleanliness standard IEC 61300-3-35, and shall be supplied with appropriate end caps for their connectors on either end.
- (d) The manufacturer's name must be printed on the outer jacket / sheath of the patch cord. Party should have manufacturer certificate from the authorized laboratories / organizations.
- (e) Individual test reports for both connectors of the patch cord should be printed on a sticker and stuck just below the connector boot on both ends. The test report should mention the following:
 - (i) Actual Insertion Loss value in dB.
 - (ii) Actual Return Loss value in dB.
 - (iii) Wavelength at which both the Insertion Loss and the Return Loss are tested.
 - (iv) Unique serial number for each connector with date to ensure traceability. The printing on the sticker should be of durable quality.
- (f) The internal/ lab test reports in support of above mentioned technical parameters shall be provided by the supplier.

14.7 TELECOMMUNICATION MANAGEMENT NETWORK / NETWORK MANAGEMENT SYSTEM

The Contractor shall provide a Telecommunications Management Network System (TMN) for operational support to the FOTS. 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 a single TMN for all the NEs (Network Elements) such as MPLS-TP equipment etc. The bidder shall provide details of the offered TMN in the bid.

All types of Equipment (MPLS-TP, Switch, Amplifiers etc) required under the project shall be accessible through the single NMS supplied along with Equipment.

14.7.1 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 SNMP/ CORBA-TMF-814 /XML compliant.

The supplied TMN system shall be capable of handling all management functions for at least 200% of the final network elements supplied under this package, also the TMN system shall be capable of handling the fully expanded equipment. If the bidder is upgrading existing TMN system, the upgraded TMN system shall be capable of handling all management functions of fully expended equipment for at least additional 200% of the final network elements supplied under this package. The cost of license to meet these requirements shall be included in the network element cost.

14.7.2 General Operational and Functional Requirements

The TMN system shall be multi-user system and based on Graphical User Interface.

It should be possible to have a view of selected sub-networks/rings controlled by the TMN system as per requirement. By zooming-in, it shall be possible to drill down to module-level in each NE for configuration and fault management. The same shall be provided through user-friendly GUI commands.

The TMN system shall provide the complete view of the network elements and the interconnecting links. The TMN system shall have the ability to include the network elements and the links in the visual/graphical map of the domain. The visual maps shall display the elements and the links in different colour depending upon the status of the links. For example, green colour for healthy and amber/yellow colour for degraded condition and red for unhealthy condition may be used.

It shall provide the ability to drill down to the individual element, then to subsystem, then to card and then to port level configuration template from the domain-map by clicking on the icon of the network element.

It shall be possible to generate customized reports for various types of faults, performance history, security management etc. It shall be possible to generate reports at various client levels to facilitate monitoring of performance statistics in a pre-defined/ customized format. It shall be possible to generate and define the formats at any time, based on network needs.

The TMN shall support correlation (filtering and suppression) to avoid multiple alarms from a single source of failure within the sub network. Single Alarm shall be provided for the events that are correlated and are due to a common cause.



It shall be possible to execute any schedulable administrative command i.e. NE backup, software download, performance, operator log-in/ log-out etc., at any time by attaching a time tag to the command and it shall be executed when the Network real time matches the time tag. It shall be possible to define both time and date. If no date is mentioned, the command shall be executed daily at the time mentioned.

The response time for query/command on any operator terminal, local or remote shall be indicated by the vendor. Update about topological information on the terminals, the response time shall be indicated by the vendor. The response time shall however, be reviewed depending upon total NE load and topology by Employer during testing.

14.8 MANAGEMENT FUNCTIONS

The TMN shall support and provide the following Management functions:

- (a) Configuration Management
- (b) Fault Management
- (c) Performance Management
- (d) Security Management
- (e) Inventory Management
- (f) Software Management

The equipment shall support the generic requirement of fault, configuration and performance requirements as per clause 6.1 of ITU-T G.872. The equipment shall support the management aspect of the optical network as specified in ITU-T G.874 and G.874.1. The functions mentioned below shall be available across the entire network on a seamless end-to-end basis comprising of all the network elements being procured under this package.

14.8.1 Configuration Management

Configuration management is concerned with management, display, configuration, provisioning and control of the network configuration and shall be implemented in accordance with ITU-T Rec. G.874. Minimum specific requirements that shall be satisfied include the following:

- (a) Provide tools to establish, maintain, update, delete and retrieve the topology and configuration information and provide graphical maps depicting the configurations. It shall be possible to inspect and configure all the appropriate parameters of the Network Elements through the Graphical User Interface.
- (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) Creation of Network Element (NE) in Network Management / Network Editor Domain & complete NE Configuration. Network Elements includes all Amplifiers, to be supplied under the project. Provide verification testing to support new equipment installation.



- (e) Update, deletion and retrieval of the managed network topology data.
- (f) Configuration of various error/fault/alarm generation threshold;
- (g) Configuration and management of in-band secured management channel for their management from NMS
- (h) Configuration for synchronization;
- (i) Configuring end to end Label Switched Path (LPS) and Pseudo wire (PW) trail and assigning network resources to the trail. Enabling/disabling of protection switching of trails.
- (j) Provide tools for configuring end to end circuits and to configure protection for each of them individually, and supports Configuration & management of features like:
- (k) E-Access: Access EPL, Access EVPL E-LAN: EPLAN,EVP-LAN
- (l) E-LINE: EPL,EVPL
- (m) E-Tree: EP-Tree, EVP-Tree
- (n) Provide tools for downloading software upgrades from remote using TMN.

14.8.2 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoral and reporting on all the network equipment including amplifiers, systems, and links and shall be implemented in accordance with latest and relevant ITU-T standards. 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. Alarm notification shall include type, occurrence, severity, probable cause and clearing.
- (b) Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity. Each failure and clearance shall be timestamped.
- (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 required to minimize the proliferation of alarms caused by a single, common event.
- (d) Bypass failures through the use of automatic failover to redundant equipment where possible and through operator-initiated actions where automatic failover is not possible. The criteria for failover shall be configurable.
- (e) Storing and processing of historical alarm information for 35 days minimum. Retrieving functions with filtering capabilities for historical alarms and events shall be provided. FCS errors for Ethernet clients shall be provided.
- (f) Assigning alarm severity i.e. Critical, Major, Minor & Deferred.
- (g) Provision to create a customised entity under fault management window to monitor alarms of specific set of customers, set of links, geographical area etc.



14.8.3 Performance Management

Performance management is concerned with evaluation of the use of network equipment and their capability to meet performance objectives and shall be implemented in accordance with latest and relevant ITU standards. Performance monitoring shall conform to ITU-T Rec. M-2100, M-2101, M-2120, G.821, G.826, G.828, G.829 and RFC 2544.

The equipment shall support ODU-k/ OTU-k related performance requirements specified in ITU-T G.709, G.8201 and G.7710. The 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, The BER of each link, together with other data measured at each node, shall be available on operator request. A suitable user interface shall be provided for generating report.
- (b) The details for report format shall be finalised during detailed engineering. Performance history for minimum 35 days shall be supported with configurable launch time and performance evaluation/integration period. It shall be possible to set the performance thresholds from 1×10^{-5} to 1×10^{-15} through the TMN/LCT in a continuous manner in the specified BER range as above.
- (c) Provide end to end latency of Ethernet links at circuit level.
- (d) There shall be provision for both, near end performance monitoring and far end performance monitoring at lambda level and circuit level.
- (e) Monitor point to point & end to end signal quality and history at individual wavelength level. Provide operator controls to monitor performance of specified events, measures, and resources.

Specifically provide displays to permit the operator to:

- (i) A suitable user interface shall be provided for generating above reports. The details for report format shall be finalised during detailed engineering. Select/deselect network equipment, 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) Monitor optical parameters (signal levels) of all optical interfaces and generate alarms. Set multiple thresholds on certain performance parameters of electrical and optical signals. 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.
- (viii) Performance data provided is limited to what is available from the equipment manufacturer.
- (ix) 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.



- (x) Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics

14.8.4 Security Management

The TMN system shall provide adequate security to the data while accessing the system as per the following details:

- (a) The TMN shall have the capability of supporting the management of Network through local and remote Operators. The authorizations and the privileges of the operators (Remote and Local) shall depend upon the Login and Password.
- (b) a. Low level protection for read only access to faults and performance information.
- (c) b. Medium level protection for access to configuration status and features.
- (d) c. High level protection for control of access to change in the configuration and control parameters.
- (e) Network management security features shall include operator authentication, command, menu-restriction and operator privileges. The TMN shall support multi-level passwords as below-
 - (i) TMN shall allow the System Administrator to define the level of access to the network capabilities or feature for each assigned password. TMN shall block the access to the operator in case of unauthorized commands being tried for five consecutive times. TMN shall also not allow the entry into the system in case wrong password is provided more than five consecutive times during the login.
 - (ii) The system administrator shall be able to monitor and log all operator activities in the TMN and Local Craft Terminal.
 - (iii) The dynamic password facility shall be provided in which the operator may change his password at any time.
- (f) All log-in and log-out attempts shall be logged in the security log file of the TMN system.
- (g) The network and the management system shall be protected against intentional or accidental abuse, unauthorized access and loss of communication.
- (h) The man-machine communication programs shall have the facility of restricting the use of certain commands or procedures to certain passwords and terminals.
- (i) The LCTs shall normally operate through the centralized TMN.
- (j) Only in the case of failure of link between the LCT location and the TMN, the LCT should be able to supervise/monitor the local assigned to it.
- (k) It should be mandatory for the system to have a record of all logins, operation and maintenance command logs which shall include the actual command given, who gave the command, when was it given with date and time and from where for a period of at least twelve months after which a backup should be possible under system administrator command.
- (l) It shall be possible to define multiple domains for purposes of monitoring and control. It shall also be possible to make domain based on the circuit(s) of a particular customer. Means shall be provided to ensure only one authorized operator has access to change in the configuration and control parameters for a selected domain of the network.



- (m) The system shall be able to back up programmes and data and restore the same to and from external storage media. Anti-virus packages, if required, shall also be provided.
- (n) The DCN network shall transmit all management data encrypted. Encryption shall be done by 128 bit encryption key.

14.8.5 Inventory Management

Under inventory management functionality, the following shall be supported:

It shall indicate complete view of the network elements and interconnecting links. It shall indicate absence or presence of any physical module in hardware elements. It shall also indicate the usage of module i.e. how many ports are in use, which interface is in use and which are free to be used etc.

- (a) TMN shall be able to discover and keep the device information.
- (b) Keep track of any change in network inventory and generate report chronologically.
- (c) The inventory information shall be provided to Network Management Layer (NML) / Service Management Layer (SML) so that SML is able to create and activate a service to the customer automatically. This shall also assist SML in providing the network inventory to which SML shall add the customer identification and maintain this information in the database.
- (d) Generate report based on query e.g. module type, network element location etc. A suitable user interface shall be provided for generating report. The details for report format shall be finalised during detailed engineering.

14.8.6 Software Management

It shall be possible to carry out the following tasks under the software management function:

- (a) Loading of new system software.
- (b) Manage different versions of software.
- (c) Shall have the capability of managing multiple versions of software for individual elements. In this case, one software version shall remain active and other versions shall be passive.
- (d) Installation of software patches.
- (e) Examine contents of all system memory and disk memory.
- (f) At the time of downloading the software, the message shall be displayed that the software has been downloaded successfully or failed and at what stage.
- (g) The operator terminals (local & remote) shall not allow loading of any software without the terminal administrator's authorization.
- (h) It shall support FTP/TFTP for downloading of Software, configuration, patches etc. to the Network Element.
- (i) It shall enable operations like changing the system configuration, reconfiguration of input and output devices, loading a new software package, etc. Both automatic and manual reconfiguration capabilities shall be available.



- (j) All commands which are executed over the TMN program or data shall be logged in a file (read only) and it shall be possible to retrieve the same on demand whenever required using Man-Machine Commands. The file usage of up to 50%, 75% and 90% shall generate alerts in the server platform, of suitable category prompting the operator to initiate the backup operation.
- (k) It shall be possible through a single Man-Machine Command to obtain a list and the total number of equipment of a particular domain in a state (e.g. in-service, blocked etc.).
- (l) While working on system level commands, it shall be possible to log recent user operations and display the same through the GUI.
- (m) Local & remote software download via management system to NEs and LCT shall be possible, including the means of identification of software module versions. No loss of data/traffic and connection-map shall take place during the software downloading process.

14.9 COMMUNICATION CHANNEL REQUIREMENT AND INTEGRATION

Communication requirements for TMN system have not been considered separately 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 SDH system shall be transported through the new communication network, wherever required, up to the NMS location. The NMS information of the new MPLS-TP 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.

14.10 CRAFT TERMINAL

Each node on the network shall include provision for connecting a Local Craft Terminal, i.e. a portable laptop to support local commissioning and maintenance activities. It shall also be possible to perform maintenance activities on remote stations. Through the use of this Local Craft terminal, the operator shall be able to:



- (a) Change the configuration of the station
- (b) Perform tests
- (c) Get detailed fault information
- (d) Download configuration data, software upgrades
- (e) Upload alarm data and other system related data from the network element
- (f) Monitor performance parameter of optical ports.

The portable computer shall be connected to a V.24/V.28 interface or Ethernet interface or USB available at network element. Portable (laptop) computers, each complete with necessary system and application software to support the functions listed below, shall be supplied as per quantity (tentative) in BoQ.

- (g) There shall be a provision at each network element for connecting to a Local Craft Terminal (LCT). This feature shall be available for all network element equipment proposed by the Bidder. The Local Craft Terminal shall be connected through a serial V.24/V.28 or Ethernet interface or USB.
- (h) The Local Craft Terminal software shall be executable on a portable, laptop PC equipped with latest supported Microsoft Windows or Linux (or its variant) operating systems.
- (i) It shall be possible, once connected to one Network Element, to access other network elements by way of addressing.
- (j) It is desired that the Local Craft Terminal and TMN shall have the same Graphical User Interfaces and they shall behave in the same manner regardless of whether they are executing on a Local Craft Terminal or on TMN.
- (k) The Local Craft Terminal shall provide Graphical User Interfaces that enables the user to interact with the embedded software in the network element in such a way that the user can:
 - (iv) Inspect all data residing in the network element, being registers, files or database elements;
 - (v) Set all the appropriate data elements, as appropriate, within the network element.
- (l) The Bidder shall state if there are any functionalities (or registers, files or database elements) for which the Graphical User Interface of the Local Craft terminal cannot be used and the means by which such functionalities are then reached

14.11 HARDWARE REQUIREMENTS

14.11.1 Server, Workstation and Craft Terminal

The TMN hardware should be based on either UNIX/LINUX/SOLARIS or latest Windows server platform with Sun/HP/IBM or any other reputed make Servers and Work stations. The software should be user friendly. The sizing of the server/processor, RAM, no. and type of interfaces, RAID/HDD etc. shall be commensurate with the network size, no. of con-current users, response time etc. The bidder shall provide details of hardware, software and server sizing calculations along with the bid. Servers, workstations shall have DVD R/W drives for data backup and restoration. Servers along with associated hardware shall be rack mounted.



Work station CPU enclosures shall be desktop type (Preferably All-in one PC and shall include available expansion slots except for the Craft Terminal which shall be a laptop. All the VDUs including that of server and Work stations shall be 23.8" Full HD colour LED panels. The minimum requirement for of ach remote terminal shall be as follows:

- (a) Intel 10th Generation Core-i7 processor
- (b) Licensed MS Window with Anti-Virus provisioning
- (c) 32GB DDR-4 1333 MHz SDRAM
- (d) 256 GB SSD and 1TB HDD
- (e) 24-inch Full HD LED monitor
- (f) Ethernet 10/100 adapter with RJ-45 connector

Craft Terminal (Hardware & Software) shall be supplied along with associated items like: cable, connectors, licensed software etc. The Craft Terminal (hardware) shall be a professional grade device complying with MIL-STD-810G reliability & stability, from a prominent Laptop/ Computer manufacturer (like: HP, DELL, Lenovo etc) and shall be supplied along with latest licensed operating system (OS).

The minimum requirement of each remote terminal shall be as follows:

- (a) Intel 10th Generation Core-i7 processor
- (b) Licensed MS Window with Anti-Virus provisioning
- (c) 16GB DDR-4 1333 MHz SDRAM
- (d) 512 GB SSD
- (e) 14-inch Full HD LED
- (f) Ethernet 10/100 adapter with RJ-45 connector
- (g) Minimum 6 hours Battery Life

14.11.2 Local / Remote Operator Consoles

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 a work station (refer Section 14.11.1 above) and suitable interfaces to the TMN as stated above.

14.11.3 Power Supplies

The TMN system shall use 230 volt 50 Hz AC or -48 volt DC for its operation.

14.12 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.



14.12.1 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.

14.12.2 Application 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.

14.12.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

14.12.4 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.

14.12.5 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.

14.12.6 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.

CHAPTER 15:
REMOTE TERMINAL UNIT (RTU)



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CHAPTER 15: Remote Terminal Unit (RTU)

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
15.1	General	1
15.1.1	Scope of Work	1
15.2	Remote Terminal Unit (RTU)	1
15.2.1	Overview of Required function and Design	1
15.2.2	Design Standards	1
15.3	Monitoring and Control Target of the RTU.....	2
15.3.1	Substation.....	2
15.3.2	Distribution Lines	2
15.4	Overview of Data Communication Equipment and Stations.....	2
15.4.1	Required Communication Interface per Station	2
15.4.2	Data not received from the Gateway.....	3
15.5	Collected Data and Received Data Management	3
15.5.1	Supervision/Status	3
15.5.2	Control	3
15.5.3	Protocol.....	3
15.5.4	Point Table	3
15.5.5	Seamless Data Communication with Master Station	4
15.6	Wire and Panels	4
15.6.1	Environmental Requirements.....	4
15.6.2	Noise Level	4
15.6.3	RTU Size and Expandability	4
15.6.4	RTU Panel	4
15.6.5	Interconnections	5
15.7	Modules in RTU.....	6
15.7.1	Input DC Power Supply Module	6
15.7.2	CPU module	6
15.7.3	Analog Inputs modules	6
15.7.4	Digital Input (DI) Module	7



15.7.5	Digital Output (DO) Module.....	7
15.7.6	Control Output Interposing Relays (Double Contact Digital Output)	8
15.7.7	Wiring/Cabling Requirements	8
15.7.8	Terminal Blocks.....	8
15.7.9	Time facility	9
15.8	Portable Configuration and Maintenance Terminal (If Applicable)	9
15.9	RTU Testing	9
15.9.1	Type Tests.....	9
15.9.2	Routine Tests	10
15.9.3	Field Tests.....	10
15.9.4	Availability Tests.....	10
15.10	Approval Drawings	12



15.1 GENERAL

15.1.1 Scope of Work

The Contractor shall supply RTU and the associated equipment. The Contractor shall be responsible for supplying all hardware, software, installation, cabling and field implementation for RTU as defined in this Specification.

The RTU shall be installed in the control room at Birauta Substation (Local Station).

Necessary additions/modifications in Master Station for SCADA System, databases, and displays for integration of RTU shall be in the Employer's scope.

The Contractor shall also provide complete documentation, training and testing to fully support the hardware and software provided.

15.2 REMOTE TERMINAL UNIT (RTU)

15.2.1 Overview of Required function and Design

(1) Required Basic Function

- (a) The RTU receives, buffers, processes, and transmits 11kV system status data from the substation's SAS. It has functions for data reception, buffering, and editing. Status changes are transmitted without delay, while measurement data is sent periodically.
- (b) The RTU also receives, buffers, processes, and transmits RMU status data from FRTUs via SDH/MPLS. It performs data reception, buffering, and editing functions. Status changes are transmitted without delay, and measurement data is sent periodically.
- (c) The RTU receives control signals for the 11kV switchgear from the Master Station or Local SCADA and immediately transmits them to the SAS. It converts these signals into a format compatible with the SAS.
- (d) Similarly, when the RTU receives control signals for RMU switchgear from the Master Station or Local SCADA, it promptly sends them to the corresponding RMU/FRTU. The RTU converts these signals into a format compatible with the RMU/FRTU.

(2) Required standardized design

- (a) The design shall use as much standard hardware and software as possible; cabling should be minimized.
- (b) The system design should be as much modular as possible.

15.2.2 Design Standards

The RTUs shall be designed in accordance with applicable International Electro-Technical Commission (IEC), Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), and National Equipment Manufacturers association (NEMA) standards, unless otherwise specified in this Technical specification. In all cases the provisions of the latest edition or revision of the applicable standards in effect shall apply.



15.3 MONITORING AND CONTROL TARGET OF THE RTU

The RTU's monitoring and control targets are geographically divided into two places as (a) the outgoing feeder switchgears at substations, and (b) the RMUs (Ring Main Units) on distribution lines.

15.3.1 Substation

The substation will be equipped with a Substation Automation System (SAS). Data collection and control commands to the switchgears will be executed by the SAS through the GW(Gateway).

Signals that cannot be collected by the SAS, such as the RTU's control place selection switch (REMOTE/LOCAL) or control power supply anomalies, will be managed through the RTU's PIO (Process Input/Output) implemented DI (Digital Input module).

Note: PIO includes DI, DO (Digital Input, Output), and AI, AO (Analog Input, Output). Some manufacturers may refer to DI as Binary Input.

15.3.2 Distribution Lines

The RMUs on the distribution lines are equipped with FRTUs (Feeder RTUs) to collect the status of equipment within and around the RMUs. These data are sent to the RTU.

Control signals for the switchgears within the RMUs, issued from the Master Station or Local Station (Local SCADA), are transmitted through the RTU to the FRTU.

Since there are multiple RMUs, and the number of RMU may be increased near future, the system configuration should be designed to accommodate such expansions.

15.4 OVERVIEW OF DATA COMMUNICATION EQUIPMENT AND STATIONS

15.4.1 Required Communication Interface per Station

The RTU shall have interface function between the master station substation, field station, and field station.

Substation outgoing feeders shall be monitored and controlled from Master station SCADA and Local SCADA through the GW.

The data are collected by the SAS. And control command are issues to the SAS.

The Communication Targets and required interfaces are summarized in the following table.

Communication Target	Target Communication Terminal	Physical Interface	Applicable Protocol
Master Station (DCC)	SDH/MPLS	Ether Net	60870-5-104
Local Station SAS	GW (Gateway)	Ether Net	60870-5-104
Field Station RMU	SDH/MPLS	Ether Net	60870-5-104
Local Station Local SCADA	PC (Personal Computer)	Ether Net	60870-5-104
Local Station, Feeder SCADA	PC (Personal Computer)	Ether Net	60870-5-104



15.4.2 Data not received from the Gateway

(1) Data Input/Output and Interface Circuit Implementation

Certain data not available from the Gateway must be input or output directly via DI/DO modules installed in the RTU from the respective devices.

This applies in scenarios such as Gateway failure, power supply anomalies, or the status of the REMOTE/LOCAL switch installed in the RTU.

The implementation of the necessary interface circuits for these inputs or outputs, including modifications to the respective devices, is included in the Scope of Work.

(2) Interposing device

If necessary, signal transducers or interposing device, etc., shall be implemented.

(3) Direct IED Data Acquisition

The RTU should have the capability to directly obtain data from IEDs using the IEC 61850 protocol if data cannot be obtained from the Gateway.

The RTU should have the capability to directly obtain data from IEDs using the MODBUS TCP or MODBUS RTU protocol if the IED devices have capability to apply such protocols.

This ensures continuous data availability and system reliability.

15.5 COLLECTED DATA AND RECEIVED DATA MANAGEMENT

15.5.1 Supervision/Status

The data received from the SAS and RMUs is to be edited and managed to meet the requirements of the Master Station and Location Station (Local SCADA)

15.5.2 Control

Additionally, control signals from the Master Station and Local Station (Local SCADA) should be edited and managed to conform to the receiving format of the SAS and RMUs.

15.5.3 Protocol

The data transmission and reception will apply the IEC60870-5-104 protocol.

15.5.4 Point Table

Refer to the attached diagram for the data to be transmitted and received. The point tables included in the attached diagram are typical examples. After confirming the detailed specifications of the 11kV switchgear, SAS, and RMU to be adopted, and comparing them with the requirements of the DCC, create the Point Table Address Table.

Place	Title:	Drawing No.
Substation	Substation Point Table	BIR-DL-42001
RMU	RMU Point Table	BIR-DL-42002



15.5.5 Seamless Data Communication with Master Station

- (a) The Contractor shall also be responsible for integration of supplied RTUs with the existing SCADA/EMS System of the Employer as per the specified protocols and interoperability profile.
- (b) The RTU shall be used for real-time supervision and control of substation/ power plant through SCADA system. The time stamps on the data shall be synchronized with Master Station.
- (c) However, the system supplied by the vendor should satisfy all the functional requirements of this Specification.
- (d) The Contractor shall supply all the necessary items and provide a complete RTU design that meets all the Employer's functional requirements defined in this Specification.

15.6 WIRE AND PANELS

15.6.1 Environmental Requirements

The RTU will be installed in control room buildings with no temperature or humidity control.

The RTUs shall be capable of operating in ambient temperature from -5 to +55-degree C with rate of temperature change of 20-degree C/hour and relative humidity less than 95%, non-condensing.

At some locations, environmental temperature may go below -5-degree C for which the Contractor shall take suitable measures for successful operation of RTU.

15.6.2 Noise Level

The audible noise generated by the RTU equipment shall not exceed 50 dbas one meter from the enclosure.

15.6.3 RTU Size and Expandability

The software and the database shall be sized to accommodate growth within the ultimate sizing parameters as defined in this specification for the RTU without requiring software or database structure regeneration.

The point counts for the RTUs have been defined in the BOQ. The RTU shall have additional wired available reserve capacity of twenty percent (20%) for each type of points defined in the BOQ.

This reserve capacity shall be used without any additional hardware such as I/O cards and terminal blocks.

The I/O modules here mean Status Input module, Analog input module and the Control output module.

Other modules, such as processor module, racks etc. as required to meet the overall expandability requirement defined above shall also be supplied by the Contractor.

15.6.4 RTU Panel

The Contractor shall provide RTU Panels along with complete accessories. Generally, MFTs/MFMs will be housed in the C&R panels and the Employer may at his discretion prefer to install the interposing control relays & interface terminal blocks etc., in the RTU panel. The panels shall meet the following requirements:



- (a) Shall be free-standing, floor mounted and height shall not exceed 2100 mm.
- (b) Shall have maintenance access to the hardware and wiring through lockable full height doors.
- (c) Shall have the provisions for bottom cable entry
- (d) The safety ground shall be isolated from the signal ground and shall be connected to the ground network. Safety ground shall be a copper bus bar. The Contractor shall connect the panel's safety ground of to the Employer's grounding network. Signal ground shall be connected to the communication equipment signal ground.
- (e) All panels shall be supplied with 110 Vac, 50 Hz, single-phase switch and 15/5A duplex socket arrangement for maintenance.
- (f) All panels shall be provided with an internal maintenance lamp, space heaters and gaskets.
- (g) All panels shall be indoor, dust-proof with rodent protection, and meet IP41 class of protection.
- (h) There shall be no sharp corners or edges. All edges shall be rounded to prevent injury.
- (i) Document Holder shall be provided inside the cabinet to keep test report, drawing, maintenance register etc.
- (j) All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame retardant material and shall not produce toxic gasses under fire conditions.
- (k) The structural frame of the panels shall be of cold rolled sheet steel of thickness not less than 3 mm for the weight bearing members of the panels such as base frame, front sheet & door frames and 2mm for sides, door, top and bottom portions.
- (l) All sheet steel work shall be degreased, pickled, phosphated in accordance with IS6005. The phosphate coating shall be sealed with application of two coats of ready mixed, staving type zinc chromate primer. Two coats of synthetic enamel paint (RAL7032 shade) shall be applied both in the exterior and the interior of the panel.

15.6.5 Interconnections

All cabling between component units of the RTU, RTU to interface cabinet, RTU to MFTs/MFMs and to the Employer control and relay panels (located in the substation control room) shall be supplied and installed by the Contractor and shall be shown on Contractor supplied drawings.

Plug-type connectors with captive fasteners or compression type connectors shall be used for all internal interconnections.

The connectors shall be polarized to prevent improper assembly. Each end of interconnection cables shall be identified by a marker which includes the cable number and the identifying number and location of each of the cable's terminations.

This information shall match with the Contractor's drawings.

Adequate space and hardware shall be provided for routing of the field wiring within the enclosures.

Contractor wiring within enclosures shall be neatly arranged and shall not be directly fastened to the enclosure frame.



All internal interconnection wiring and cables shall be routed separately from field wiring to the RTU terminals & power wiring.

All wiring shall use copper conductors and have flame retardant insulation. Conductors in multi-conductor cables shall be individually color coded.

The use of non-flammable, self-extinguishing, plastic wire troughs is permissible. Metal clamps must have insulating inserts between the clamps and the wiring.

Wiring between stationary and movable components, such as wiring across door hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wiring.

15.7 MODULES IN RTU

15.7.1 Input DC Power Supply Module

The RTU will be powered from a 48 V DC (+ve earthed) system. The RTU shall not place additional ground on the input power source. The characteristics of the input DC power supply shall be

- (a) Nominal voltage of 48 V DC with operation between 41 and 60 V DC.
- (b) Maximum AC component of frequency equal to or greater than 100 Hz and 0.012 times the rated voltage peak-to-peak.

The RTU shall have adequate protection against reversed polarity, over current and under voltage conditions, to prevent the RTU internal logic from being damaged and becoming unstable causing mal-operation.

15.7.2 CPU module

The RTU shall have redundant CPU and Power Supply unit so that the RTU can communicate with the Master Stations even when one of the redundant units fails. The Power Supply units shall be UPS equipment to be installed in the Substation work. RTU panel will receive 110 V AC from the UPS and convert it to 48 V DC using converter unit installed in the RTU panel.

A failover process shall cause the assignment of all the functions of the failed unit to the healthy unit.

The failover between the two redundant units shall not require any manual intervention and shall not cause any interruption in the functioning of RTU.

The failover process shall not take more than 30 seconds after the failure of primary CPU. All the functions of RTU shall be operational within 30 seconds of the failover operation i.e, within one minute from the time of failure of primary CPU.

15.7.3 Analog Inputs modules

The RTU shall accommodate analog inputs which are unipolar or bipolar, 2-wire ungrounded differential signals. All analog inputs are of +4 to +20 mA. However, the RTU shall be able to accept other standard analog input ranges (0 to 5V, 0 to 10V, 0 to 10mA, -10 to +10 mA).

The RTU shall make all appropriate signal level conversion and conditioning to allow full utilization of analog inputs and meaningful reasonability checking.



The analog-to-digital converter shall have a minimum resolution of 32767 counts (sign plus 15 data bits).

Each type of analog input shall be converted with full resolution.

The RTU shall monitor the drift in characteristics of its ADC and mark the analog points with a drift quality code if a drift is detected. This drift quality code shall be sent to the master station also.

The RTU accuracy, for analog input measurement, shall be 99.8% or better at 25-degree C ambient temperature. Mean accuracy shall drift no more than 0.002% per degree C within the temperature range of -5 to +55-degree C. Determination of accuracy shall be made while the analog multiplexer is operating at rated speed.

Each input shall have suitable protection and filtering to provide protection against voltage spikes and residual current at 50 Hz, 0.1 ma (peak-to-peak) and overload.

Loading up to 150% of the input value shall not sustain any failures to the RTU input. The total input impedance offered by the RTU shall not be greater than 250 Ω (for +4 to +20 mA range).

All analog inputs shall be scanned by the RTU from the field at least at 1 second periodicity.

15.7.4 Digital Input (DI) Module

RTU DI module shall accept isolated Dry Contacts, internally wetted from 24 to 60V DC.

The RTU shall be set to capture contact operations of 20 ms or more duration. Operations of less than 20 ms duration shall be considered no change (contact bounce condition). The RTU shall accept two types of status inputs i.e. Single point Status inputs and Double point status inputs.

The RTU shall store all status changes detected for retrieval by the master stations.

For communication delays or short-term failure of communications with a master station, the RTU shall store a minimum of 300 status change events for substation.

RTU shall store a minimum of 60 status change events for each RMU.

The RTU shall report any overflow of this status change buffer to the master stations.

Overview of signal interface are shown in the table below.

Item	Value
Number of input	16 binary inputs and common return
Input interface:	Galvanic isolated via opto coupler
Input Indication:	1 LED per input
Applicable voltage range	24-60 VDC
Time stamping:	1ms
Insulation Voltage	1,500V AC to 2,500V AC

15.7.5 Digital Output (DO) Module

The output module will be implemented if necessary.

If the relay contacts of the OUTPUT module are insufficient for switching the load, an interposing relay should be added. Ensure adequate electromagnetic noise countermeasures are implemented to prevent any impact on electronic circuits.

Overview of signal interface are shown in the table below.

Item	Value
Number of output:	not less than 4 command outputs, with relay outputs
Output indication1:	LED per output
Max. Switching voltage:	150 V DC
Continuous current:	5A
Max. breaking current:	5A at 30 V DC, resistive load
Insulation Voltage	1,500V AC to 2,500V AC

15.7.6 Control Output Interposing Relays (Double Contact Digital Output)

If the equipment controlled by the RTU cannot be operated by the output voltage or output current of the RTU's DO (Digital Output) module, an interposing relay should be implemented. In such cases, ensure that the relay used is compatible with the equipment being controlled.

If the operation of the interposing relay affects the RTU or other electronic devices, appropriate measures must be taken to mitigate those effects.

15.7.7 Wiring/Cabling Requirements

Shielded (screened) cables shall be used for external Cabling from the RTU panels. These external cables (except communication cables) shall have the following characteristics.

- All cables shall have stranded copper conductor.
- Minimum core cross-section of 2.5 mm² for PT cables, 4 mm² for CT cables and 2.5 mm² for Power & Control outputs and 1.5mm² for Digital Status inputs, transducer mA current output
- Rated voltage U_o/U of 0.6/1.1KV
- External sheathing of cable shall have oxygen index not less than 29 & temperature index not less than 250. Cable sheath shall meet fire resistance test as per IS 1554 Part- I.
- Shielding, longitudinally laid with overlap.
- Dielectric withstand 2.5 kV at 50 Hz for 5 minutes
- External marking with manufacture's name, type, core quantity, cross-section, and year of manufacture.

15.7.8 Terminal Blocks

Terminal blocks shall be having provision for disconnection (isolation), with full-depth insulating barriers made from moulded self-extinguishing material.

Terminal blocks shall be appropriately sized and rated for the electrical capacity of the circuit and



wire used. No more than two wires shall be connected to any terminal.

Each analog input signal, digital status input and digital output signals shall require two terminals per point plus a common shield termination for each cable.

All terminal blocks shall be suitably arranged for easy identification of its usages such as CT circuits, PT circuits, analog inputs, status inputs, control outputs, auxiliary power supply circuits, communication signals etc.

Terminal Blocks for CT circuits shall have feature for CT shorting (on CT side) & disconnection (from load side) to facilitate testing by current injection. Similarly, TBs for PT circuit shall have feature for disconnection to facilitate voltage injection for testing.

15.7.9 Time facility

The RTU shall have an internal clock with the stability as defined. The RTU shall be synchronized through synchronization message from master station at every 10 minutes using IEC 60870-5-101 protocol. The RTU shall support the calculation of the propagation delay dynamically by the Master station. However, all the RTUs shall have a suitable interface for receiving synchronization signals from a local GPS receiver.

The RTUs communicating over IEC-60870-5-104 shall be supplied with a GPS receiver for synchronization of RTU clock.

The RTU shall synchronize its internal clock with the master station system clock when time synchronization messages are available and shall mark all the time stamped information/data as invalid when the RTU clock is not synchronized with the Master station.

15.8 PORTABLE CONFIGURATION AND MAINTENANCE TERMINAL (IF APPLICABLE)

If necessary, the Contractor shall a Portable Configuration and Maintenance Terminal (PCMT, Laptop PC) which shall provide followings capabilities. If the following functions are included in the Network Management System (NMS) for Craft Terminal, the dedicated device and software shall not be required.

- (a) RTU Data base configuration & Maintenance
- (b) Local Operator Interface & RTU Diagnostics

15.9 RTU TESTING

15.9.1 Type Tests

A complete integrated unit shall be type tested to assure full compliance with the functional and technical requirements of the Specification. The testing sample shall include at least one of each type of cards/modules and devices. The list of Type tests to be performed on the RTU is mentioned in Table-1 & type test requirements are mentioned in Table-2

The Contractor may optionally submit type test reports for all the EMI/EMC tests conducted at accredited laboratory for review & approval by Owner. However, in the event, the type test reports are not meeting the specification requirement, Owner may ask for the type testing of any or all the above tests as required at no additional cost to the owner.



The type test of RTU with reference to functional tests shall be carried out in all cases. Contractor shall commence commercial production of RTUs after successful completion of all type tests and approval from Owner.

Further, type test reports for meters, transducers and relays shall be submitted as per relevant standards. All weather sensors shall be calibrated as per Nepal Metrological Department standards and certificate shall be submitted in this regard.

15.9.2 Routine Tests

Each complete unit shall undergo routine testing. The list of Routine tests to be performed in the factory is mentioned in Table-1.

15.9.3 Field Tests

After RTU panel installation and interface cabling with C&R panels and communication equipment, the Contractor shall carry out the field-testing. The list of field tests is mentioned in Table-1.

15.9.4 Availability Tests

After field testing, RTU shall exhibit 98% availability during test period of 500 hours. Availability tests shall be performed along with Master station. The RTU shall be considered available only when all its functionality and hardware is operational. The non-available period due to external factors such as failure of DC power supply, communication link etc., shall be treated as hold-time & availability test duration shall be extended by such hold time.

Table-1: List of Test on RTU

No	Description of the Test	Type test	Routine test	Field test
	Functional Test for RTU			
1	Check for BOQ, Technical details, Construction & Wiring as per RTU/ drawings	√	√	√
2	Check for RTU database & configuration settings	√	√	√
3	Check the operation of all Analog inputs, Status input & Control output points of RTU	√	√	√
4	Check operation of all communication ports of RTU	√	√	√
5	Check for communication with master stations or master station simulator for RTU/	√	√	√
6	Test for downloading of RTU database from Master station	√		
7	Test for RTU time synchronization from Master	√		√
8	Test Power Supply Voltage Margin, Ripple Levels and Short Circuit Protection	√		
9	Test for RTU operation with DC power supply voltage variation	√		
10	Check for auto restoration of RTU on DC power recovery after its failure	√	√	√
11	Test for RTU diagnostic feature	√		
12	Test for RTU SOE feature	√		
13	RTU Analog accuracy test for analog input	√		
14	Transducer accuracy test	√	√	
15	Test for IEC 60870-5 -104, 61850 & Modbus protocol implemented	√		
16	Test for RTU internal Clock stability	√		
17	Test for RTU Noise level measurement	√		



18	Test for Control Security and Safety for Control outputs	√		
19	Other functional tests as per technical specification requirements	√		
20	End to end test (between RTU/ & Master station) for all I/O points			√
	EMI/EMC Immunity Test for RTU	√		
21	Surge Immunity Test as per IEC 60870-2-1	√		
22	Electrical Fast Transient Burst Test as per IEC-60870-2-1	√		
23	Damped Oscillatory Wave Test as per IEC 60870-2-1	√		
24	Electrostatic Discharge test as per IEC 60870-2-1	√		
25	Radiated Electromagnetic Field Test as per IEC 60870-2-1	√		
26	Damped Oscillatory Magnetic Field Test as per IEC-60870-2-1	√		
27	Power Frequency Magnetic Field Test as per IEC-60870-2-1	√		
	Insulation Test for RTU			
28	Power frequency voltage withstand Test as per IEC 60870-2-1	√		
29	1.2/50 μ s Impulse voltage withstand Test as per IEC 60870-2-1	√		
30	Insulation resistance test	√		
	Environmental Test for RTU			
31	Dry heat test as per IEC60068-2-2 / 2-3	√		
32	Damp heat test as per IEC60068-2-78	√		
33	Cold Test as per IEC60068-2-1	√		

Note: Test level for above type tests are elaborated in Table-2

Table-2: RTU Type Test Requirements

No.	Test Name	EUT status	Test Level	Power Supply Points		I/O Points	Passing Criteria
				CM	DM		
1	Surge Immunity Test	ON	Level 3	2 kV	1 kV	2 kV	A
2	Electrical Fast Transient Burst Test	ON	Level 3	2 kV	-	1 kV	A
3	Damped Oscillatory Wave Test	ON	Level 3	2.5 kV	1 kV	2.5 kV	A
4	Electrostatic Discharge Test	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode			A
5	Radiated Electromagnetic Field Test	ON	Level 3	10 V/m electric field strength			A
6	Damped Oscillatory Magnetic Field Test	ON	Level 3	30 A/m at 1MHz of magnetic field strength			A
7	Power frequency magnetic field	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)			A
8	Power frequency voltage withstand	OFF	-	1 KVrms for 1 minute			No break down or



					flashover shall occur
9	1.2/50 μ s impulse voltage withstand	OFF	-	2 kVp	No break down or flashover shall occur
10	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 V DC Megger before & after Power Freq & Impulse voltage withstand tests	As per manufacturer standard
11	Dry heat test	ON	-	Continuous operation at 550 C for 16 hrs.	0
12	Damp heat test	ON	-	at 95% RH and 400 C for 16 hrs.	0
13	Cold test	ON	-	Continuous operation at 00 C for 96 hrs.	0

Note:

- (a) EUT: Equipment Under test
- (b) CM: Common Mode
- (c) DM: Differential Mode
- (d) I/O points do not include Communication Ports
- (e) Passing Criteria:

0: No failure: Normal performance within the specified limits

A: Minor failure : temporary degradation or loss of function or performance which is self-recoverable

15.10 APPROVAL DRAWINGS

At least following document shall be submitted for the approval and installation work.

Item	Description
System Architecture Diagrams	Overview of the RTU, SCADA, and other connected systems.
Electric Wiring Diagrams	Detailed diagrams showing internal electrical circuit and IO interface with associated substation facilities.
Communication Wiring Diagrams	Detailed diagrams showing how the RTU will be connected within the network and to SCADA.
Communication Diagrams	Illustrating communication links and protocols used (e.g., IEC 60870-5-104, DNP3, MODBUS).
Input/Output Points	A detailed list of all digital and analog I/O points that the RTU will monitor and control.
Point Descriptions	Description of the function of each I/O point (e.g., voltage, current, breaker status).
Data Type	Whether the point is single-point, double-point, or analog, along with update frequency.
Communication Addresses	List of RTU address assignments, data point addresses, and their corresponding SCADA system mapping.
Mapping to Protocol	Addresses mapped according to the communication protocol being used (IEC 60870-5-104, MODBUS, etc.).
Variable Names	SCADA system variable names linked to RTU points for data collection.



Supported Protocols	Documentation on supported communication protocols (e.g., IEC 60870-5-104/101, Modbus RTU, TCP).
Message Structure	Detailed description of the message formats and data encoding.
SCADA Interface Requirements	Specifications on how the RTU interfaces with SCADA, including timing, data transmission intervals, and bandwidth.
Control and Monitoring Points	The points that SCADA can control or monitor from the RTU.
Test Plan for Integration	Procedure to verify the integration of the RTU with the SCADA system, including simulation and live testing.
RTU Configuration File	A file that includes all configuration parameters for the RTU, specifically for communication and data points.
SCADA Configuration Parameters	Parameters that ensure proper data exchange between the RTU and SCADA.
Alarm Points	Detailed list of alarm points that will be monitored by SCADA, including fault and event triggers.
Diagnostic Logs	How diagnostic data will be transmitted to SCADA for real-time monitoring and fault detection.
Factory Acceptance Test (FAT) Results	Documentation showing the RTU has passed all required factory tests.
Site Acceptance Test (SAT) Plan	Plan for site testing of RTU integration with SCADA.

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CHAPTER 16:
FEEDER REMOTE TERMINAL UNIT (FRTU)



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CHAPTER 16: Feeder Remote Terminal Unit (FRTU)

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
16.1	General	1
16.1.1	Scope of Work	1
16.1.2	FRTU Architecture	1
16.1.3	Required Functions.....	1
16.1.4	Time-tagged Data Archiving.....	1
16.1.5	Time-stamped Event Archiving	2
16.1.6	Measurement Archiving	2
16.2	Communication with the Remote Control Center	2
16.2.1	Communication Protocol.....	2
16.2.2	Events Transmission.....	2
16.2.3	Communication Ports.....	2
16.3	Local Communication Networks	3
16.4	Maintenance Tools and Functions	3
16.4.1	Remote Configuration and Operating Tools	3
16.4.2	FRTU Maintenance PC.....	3
16.4.3	Portable Configuration and Maintenance Terminal (PCMT).....	3
16.4.4	Software License of FRTU and PCMT	3
16.4.5	Diagnosis	4
16.4.6	Data Loading	4
16.4.7	Parameter and Alarm Configuration.....	4
16.5	Power Switchgear Connection	4
16.6	List of Information to be Provided.....	4
16.7	Support for Future Provisions	5
16.8	Testing	5
16.8.1	Type Testing.....	5
16.8.2	Routine Testing	5
16.9	FRTU Approval Application Drawings	6



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16.1 GENERAL

16.1.1 Scope of Work

The Feeder Remote Terminal Unit (FRTU) is implemented within the RMU (Ring Main Unit) to provide remote monitoring and control of equipment inside or around the RMU via SDH/MPLS from a Master Station or Local Station. It includes interface modules for DI (Digital Input), DO (Digital Output), AI (Analog Input), AO (Analog Output), and communication with SDH/MPLS and peripheral devices. The scope of work includes all tasks required for the operational deployment of the FRTU.

16.1.2 FRTU Architecture

The FRTU architecture supports easy installation, maintenance, and expansion. It includes a Central Processing Modules (CPM) with communication functions, and Digital/Analog I/O modules. The CPM handles communication protocols, data acquisition, and time synchronization via IEC 104 protocol. I/O modules are replaceable without reconfiguration. The minimum requirement is as below:

Modules	Number of terminals	Specification	
Power Module		output 24 V DC	Input 24V -60V dc
CPM module	To have required communication ports	Ether net RS 232 RS485	
Digital Input	Not less than 32 points	Dry contact with external dc 24V supply.	The interposing relay will be applied if necessary.
Digital Output	Not less than 16 contacts	Dry contact output	The interposing relay will be applied if necessary.
Analog Input	Space for mount shall be prepared	Not less than 16 bit resolution	4-20mA DC
Analog Output	Space for mount shall be prepared	Not less than 12 bit resolution	4-20mA DC

The interposing relay will be applied if necessary

16.1.3 Required Functions

(1) Monitoring and controlling

Monitoring and controlling 11 kV RMU and neighbor devices such as DTs, GO switch, LT-pillar and etc.

Load current voltage, power and other measurable electric parameter measurement shall be sampled.

Data transmission to a remote control station (Neighbor substations and Master stations)

Event recording with time stamps

Local and remote control modes, with event storage capacity of at least 20,000 events

16.1.4 Time-tagged Data Archiving

All archived data can be retrieved locally or remotely and downloaded as a .CSV file. Event and measurement data is time-stamped to the nearest millisecond, with discrimination between events



set at 1 millisecond.

16.1.5 Time-stamped Event Archiving

Any change of information status shall generate a stored time-stamped event. The minimum storage capacity of the events to be transmitted to the remote control center shall be 200 events.

16.1.6 Measurement Archiving

Each measurement can be configured to be archived, if required. A measurement declared archived can be stored:

At regular intervals (the interval can be configured): mean or sampled value.

When the high and low thresholds are exceeded (the thresholds can be configured).

Daily: minimum and maximum daily values (the storage period can be configured: 24 hours, 7 days, and 14 days).

The measurement storage conditions (configured individually) can be combined. The minimum storage capacity shall be 20,000 measurements.

16.2 COMMUNICATION WITH THE REMOTE CONTROL CENTER

16.2.1 Communication Protocol

The control unit shall have the following communication protocols:

- (a) IEC 60870-5-104 protocol to transfer information to control center SCADA.
- (b) Modbus protocol to communicate with field MFM (Multi-Functional Meters) on RS485.

16.2.2 Events Transmission

It shall be possible to configure each time-stamped event to correspond to the appearance or disappearance of an "alarming event" or an "alarming" closure failure. A time-stamped event declared to be "alarming" establishes communication with the remote control center.

16.2.3 Communication Ports

The FRTU/control and communication units shall have the following communication ports:

Usage	Port	Protocol	Connection	Final Destination
For Maintenance	RS 232		Maintenance PC	PC
Analog and Ry status	RS 485	Mod Bus RTU	MFM, Protection Relays	
WH meter value (**1)	RS 485	MODBUS_RTU	GPRS	DCU
RMU data transaction	Ether net-1	870-5-104	SDH/MPLS	RDC/DCC
RMU data transaction	Ether net-1	870-5-104	SDH/MPLS	RDC/DCC (for redundant)
For Maintenance	RJ45	870-5-104	Maintenance PC	PC

(**1) Energy meter (WH) values will be directly sent to GPRS modem from MFM.



Three Ethernet ports for interfacing with the IP-compatible communication equipment.

One RS485 Console port for connecting an external GPRS modem.

Required 2 ports of RS485 ports to connect field IEDs / Energy Meters on RS485.

It shall be possible to increase the number of communication ports in the FRTU if required in the future.

16.3 LOCAL COMMUNICATION NETWORKS

The control unit shall have a Modbus RS485 port for communication with the IED in the RMU , such as PMUs(power monitoring units) and MFMs(multi-functional meter), protection relays and others. The Modbus protocol shall be open and configurable. Information from this slave equipment can be stored and dated when the status changes (can be configured for each event).

16.4 MAINTENANCE TOOLS AND FUNCTIONS

16.4.1 Remote Configuration and Operating Tools

Data shall be configured using a PC connected to the control unit via an Ethernet and/or USB port. It shall be possible to:

- (a) Prepare the configurations off-line and save them on a PC.
- (b) Restore a control unit configuration using a PC.
- (c) Save a control unit configuration to a PC.

It shall also be possible to configure data remotely using the operating and maintenance software supplied with the equipment in the case of GMS, GPRS, and Ethernet networks.

16.4.2 FRTU Maintenance PC

Above PC shall be performed as Maintenance tool. The FRTUs shall include the interface to support the portable configuration and maintenance terminal (PCMT). The interface shall provide easy access to allow Employer to use the maintenance terminal at the FRTUs installed in the field.

16.4.3 Portable Configuration and Maintenance Terminal (PCMT)

Contractor shall supply a Portable Configuration and maintenance Terminal (Laptop PC) which shall provide followings capabilities:

- (a) RTU Data base configuration & Maintenance
- (b) Local Operator Interface & RTU Diagnostics
- (c) Master Station and RTU simulator

16.4.4 Software License of FRTU and PCMT

The licenses shall cover all of installed devices and maintenance tool. The licenses cost shall be included in the bid price.



16.4.5 Diagnosis

The diagnosis pages shall be used to retrieve station, switch, and system data:

Measurement and status display: This page is used to view in real-time the TSS, TSD, and TM status for each switch controlled by FRTU.

Archived event retrieval.

Users can acknowledge status locally.

Protocol analyzer is used to observe the frames exchanged with the remote control center to facilitate maintenance operations.

16.4.6 Data Loading

Loading a configuration from a file saved on a PC.

Loading a new version of the communication card or protocol software with protected switching.

Unit configuration and events and measurements archived as a Word or Excel file.

16.4.7 Parameter and Alarm Configuration

Control module parameters & delayed no-voltage alarm.

Fault detector, automation & communication parameters.

General parameters (type of protocol, use of ports, type of modem, etc.).

Protocol parameters: interoperability table, alarm.

16.5 POWER SWITCHGEAR CONNECTION

Orders and information shall be transmitted from the switchgear interface to the switch control unit via a single cable connected to the enclosure by a rack-out connector mounted on the lower part of the enclosure. Each connector has a fail-safe device to prevent reversal between the various electrical controls. The socket can be "plugged" for simulation and test purposes.

16.6 LIST OF INFORMATION TO BE PROVIDED

The RMU (Field station) shall process at least the following information for remote indication and/or local display purposes:

- (a) Open/closed position, earthing of each switch.
- (b) SF6 gas-pressure low
- (c) Absence of AC voltage
- (d) Local/remote control operating mode.
- (e) Detection of phase-to-phase or earth fault current flow.
- (f) Load current measurement.



- (g) Charger fault.
- (h) Battery fault.
- (i) Motor drive 24 V supply fault.
- (j) Internal fault.

Detailed diagnosis of the status of the uninterruptible power supply (charger, batteries).

Typical IO list is shown in the attached drawing as Point list.

Title	Drawing No
RMU Point list	BIR-DL-5302

16.7 SUPPORT FOR FUTURE PROVISIONS

The FRTU must be capable of supporting PLC programming (IEC 61131-3) to incorporate self-healing grid logic for faster restoration of supply in the absence of control center SCADA.

Self-healing grid requires multiple communication support from the FRTU (simultaneous communication of FRTU with SCADA along with FRTU peer-to-peer communication).

Hence, the FRTU must support this configuration of communication to achieve the self-healing grid feature. The software shall be preferably Windows-based.

16.8 TESTING

16.8.1 Type Testing

The FRTU offered by the bidder shall have passed the required type tests at the following institute in accordance with the latest and updated IEC standards. Test certificates for the same shall be submitted along with the bid.

Internationally recognized testing institutions for RTUs/FRTUs:

- (a) KEMA (DEKRA) - Netherlands
- (b) TÜV Rheinland - Germany
- (c) Intertek - United Kingdom
- (d) SGS - Switzerland
- (e) UL (Underwriters Laboratories) - United States
- (f) DNV GL - Norway

16.8.2 Routine Testing

All tests shall be as per the latest IEC standard.



16.9 FRTU APPROVAL APPLICATION DRAWINGS

At least following document shall be submitted for the approval.

Item	Description
System Architecture Diagrams	Overview of the FRTU, SCADA, and other connected systems.
Electric Wiring Diagrams	Detailed diagrams showing internal electrical circuit and IO interface with associated substation facilities.
Communication Wiring Diagrams	Detailed diagrams showing how the FRTU will be connected within the network and to SCADA.
Communication Diagrams	Illustrating communication links and protocols used (e.g., IEC 60870-5-104, MODBUS).
Input/Output Points	A detailed list of all digital and analog I/O points that the RTU will monitor and control.
Point Descriptions	Description of the function of each I/O point (e.g., voltage, current, breaker status).
Data Type	Whether the point is single-point, double-point, or analog, along with update frequency.
Communication Addresses	List of FRTU address assignments, data point addresses, and their corresponding SCADA system mapping.
Mapping to Protocol	Addresses mapped according to the communication protocol being used (IEC 60870-5-104, MODBUS, etc.).
Variable Names	SCADA system variable names linked to FRTU points for data collection.
Supported Protocols	Documentation on supported communication protocols (e.g., IEC 60870-5-104/101, Modbus-RTU, TCP).
Message Structure	Detailed description of the message formats and data encoding.
SCADA Interface Requirements	Specifications on how the FRTU interfaces with SCADA, including timing, data transmission intervals, and bandwidth.
Control and Monitoring Points	The points that SCADA can control or monitor from the RTU.
Test Plan for Integration	Procedure to verify the integration of the FRTU with the SCADA system, including simulation and live testing.
RTU Configuration File	A file that includes all configuration parameters for the FRTU, specifically for communication and data points.
SCADA Configuration Parameters	Parameters that ensure proper data exchange between the FRTU and SCADA.
Alarm Points	Detailed list of alarm points that will be monitored by SCADA, including fault and event triggers.
Diagnostic Logs	How diagnostic data will be transmitted to SCADA for real-time monitoring and fault detection.
Factory Acceptance Test (FAT) Results	Documentation showing the FRTU has passed all required factory tests.
Site Acceptance Test (SAT) Plan	Plan for site testing of FRTU integration with SCADA.



CHAPTER 17:
SDH/MPLS SWITCHABLE OPTICAL TERMINAL



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CHAPTER 17: SDH/MPLS Switchable Optical Terminal

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
17.1	General Requirements.....	1
17.1.1	General	1
17.1.2	Required Performance of SDH/MPLS Switchable Optical Terminal.....	1
17.1.3	Scope of Works.....	2
17.1.4	System Integration	2
17.2	Technical Requirements.....	2
17.2.1	General Features	2
17.2.2	SDH Capabilities.....	2
17.2.3	MPLS Capabilities.....	2
17.2.4	Network Management.....	3
17.2.5	Power Supply	3
17.2.6	Environmental Requirements.....	3
17.2.7	Reliability and Redundancy	3
17.2.8	Scalability and Future Proofing	3
17.3	Compliance and Certification	3
17.4	Applicable Standard	3
17.5	Documentation.....	4
17.6	Training.....	5



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17.1 GENERAL REQUIREMENTS

17.1.1 General

To define the technical and operational requirements for the procurement of an optical terminal capable of switching between SDH (Synchronous Digital Hierarchy) and MPLS (Multiprotocol Label Switching) technologies for use in power transmission and distribution networks.

SDH/MPLS equipment installed in both substations and RMUs must be designed to ensure reliable communication with the existing network, without causing any issues. A thorough site survey should be conducted to confirm seamless integration with existing systems. Additionally, the equipment must be compatible with the current infrastructure to ensure easy maintenance and operation.

17.1.2 Required Performance of SDH/MPLS Switchable Optical Terminal

The SDH/MPLS Switchable Optical Terminal (referred to as "SDH/MPLS") is installed as a data terminal between Master Stations (DCC, RDC), substations, and RMUs. The SDH/MPLS is divided into two types based on its installation location:

(1) SDH/MPLS installed in substations

This facilitates data communication between the Master Station and substation, and between the substation and RMUs.

In substations, an RTU (Remote Terminal Unit) is installed, and data from the RTU is transmitted to and received from the Master Station using the SDH/MPLS.

It also handles communication of data from SDH/MPLS units installed in RMUs to the Master Station.

(2) SDH/MPLS installed in RMU

This facilitates data communication between RMUs and the substation, as well as between different RMUs.

An FRTU (Feeder Remote Terminal Unit) is installed in the RMU, and the data collected by the FRTU is transmitted to the substation via SDH/MPLS, which then forwards it to the Master Station. For remote control of RMUs, commands are sent from the Master Station, through the substation SDH/MPLS, to the RMU SDH/MPLS, where the FRTU controls the circuit breakers (CB) and load break switches (LBS).

(3) IEC607870-5-104 Protocol handling

The data transmitted and received over SDH/MPLS is collected from RTUs and FRTUs regarding power equipment. This data is transmitted using the IEC 60870-5-104 protocol. The SDH/MPLS system requires processing capabilities necessary for this transmission. The following functions are required:

- (a) TCP/IP over SDH for SDH mode
- (b) Encapsulation (VC-12, VC-4) for SDH mode
- (c) Master SDH/MPLS Cross-connect function
- (d) SDH Layer Cross-connect (TDM multiplexing at VC-12, VC-4 level) for SDH mode
- (e) Packet Layer Cross-connect (Packet switching via label or port) for MPLS mode



17.1.3 Scope of Works

To install the SDH/MPLS for substation one (1) unit and for RMUs two (2) units.

- (a) SDH Equipment (STM-4 MADM up to 4 MSP Protected directions) with suitable optical line interfaces and tributary cards.
- (b) Local Craft Terminal (Laptop) with full operational programming software and data cables.

17.1.4 System Integration

- (a) System integration of the supplied subsystems.
- (b) Integration with existing communication equipment.
- (c) System integration of the supplied equipment (termination equipment system) with existing equipment for seamless transmission of communication channels.
- (d) Integration of the supplied system with user equipment such as RTU and FRTU.

17.2 TECHNICAL REQUIREMENTS

17.2.1 General Features

Dual-Mode Operation: The device must support seamless switching between SDH and MPLS protocols.

Data Rates: The terminal should support a range of data rates, including STM-1, STM-4, STM-16, and MPLS-TP (Transport Profile).

Interfaces: The terminal should provide E1, E3, STM-N, Ethernet (10/100/1000Base-T), and 10GbE interfaces.

Protocols: Compliance with ITU-T standards for SDH (G.707, G.783) and MPLS (RFC 3031, RFC 5654).

17.2.2 SDH Capabilities

Traffic Management: Support for dynamic bandwidth management, VC-4 and VC-12 cross-connections.

Protection Mechanisms: Must include MSP (Multiplex Section Protection) 1+1, SNCP (Sub-Network Connection Protection), and ring protection mechanisms.

Synchronization: Synchronous timing must adhere to ITU-T G.813 and G.781.

17.2.3 MPLS Capabilities

MPLS-TP Support: The device must support MPLS-TP for carrier-grade transport.

QoS (Quality of Service): Support for multiple classes of service, ensuring traffic prioritization according to utility network requirements.

Label Distribution: Support for both static and dynamic label distribution protocols, including LDP (Label Distribution Protocol).



17.2.4 Network Management

Management Interface: SNMP v3, web-based GUI, and CLI access.

Monitoring: Real-time monitoring and alarm generation, with integration into existing Network Management Systems (NMS).

Software Upgrades: The device should support remote software upgrades without service interruption.

17.2.5 Power Supply

Input 48V DC

17.2.6 Environmental Requirements

Operating Temperature: -5°C to +50°C.

Humidity: 10% to 90% relative humidity, non-condensing.

EMC Compliance: Must meet IEC 61850-3 and IEEE 1613 standards for electromagnetic compatibility.

17.2.7 Reliability and Redundancy

Power Supply: Dual, hot-swappable power supply units.

System Redundancy: The terminal must include redundant switching fabrics and processing units.

MTBF: The Mean Time Between Failures (MTBF) must be a minimum of 100,000 hours.

17.2.8 Scalability and Future Proofing

Modular Design: The terminal must support modular expansion, allowing for the addition of interfaces and processing power as needed.

IPv6 Support: Native IPv6 support for future network scalability.

Backward Compatibility: Ensure compatibility with existing SDH and MPLS infrastructure.

17.3 COMPLIANCE AND CERTIFICATION

Standards Compliance: ITU-T standards for SDH, IETF standards for MPLS, and relevant IEC standards for power utility communications.

Certifications: CE, UL, FCC, RoHS, and ISO 9001 certifications must be provided.

17.4 APPLICABLE STANDARD

The following table show major applicable standard.



Standard/Document	Description
IEC 62351	Standard for the security of communication in power systems
IEC 60870-5-104/101	Protocol standard for remote monitoring and control
IEC 61850	Standard for substation automation communication
IEC 62439	Standard for redundant networks and high availability communication
IEC 61588 (IEEE 1588v2)	Standard for high-precision clock synchronization

Typical referable recommendations

Standard	Document • Description
ITU-T G.707	SDH frame structure, bit rates
ITU-T G.783	Functional requirements for SDH equipment
ITU-T G.841	Protection mechanisms in SDH networks
ITU-T G.957	Specifications related to optical interfaces for SDH
RFC 5654	Requirements for MPLS-TP, defining the operational and management requirements
RFC 5860	OAM (Operations, Administration, and Maintenance) for MPLS-TP
RFC 5951	Network management protocols for MPLS-TP
RFC 3031	Basic architecture of MPLS
RFC 3032	Encoding of MPLS label stack
RFC 5921	Architecture for MPLS-TP
RFC 5654 & 5860	Operations, management, and maintenance of MPLS-TP

17.5 DOCUMENTATION

Technical Documentation: Comprehensive manuals, including installation, configuration, and maintenance guides.

At least following document shall be submitted for the approval and installation work.

Category	Required Documents	Description
Design Documents	- Basic Design Document - Detailed Design Document - Site Survey Report	- Overview of system layout and installation locations - Detailed wiring, topology, and communication routes - Report on site conditions and existing infrastructure
Installation Documents	- Installation Manual - Installation Plan - Test Procedure Document	- Step-by-step guide for equipment installation and configuration - Installation schedule and procedure plan



		- Detailed testing procedure for both factory and on-site
Testing Documents	- Factory Acceptance Test (FAT) Report - Site Acceptance Test (SAT) Report - Test Plan	- Report on results of factory tests - Report on results of on-site tests - Plan detailing test methods and timelines
Operation & Maintenance	- Operation Manual - Maintenance Manual - Spare Parts List	- Daily operation instructions for SDH/MPLS system - Procedures for regular maintenance and troubleshooting - List of spare and consumable parts
Compatibility Documents	- Compatibility Verification Report - Standard Compliance Certificates	- Verification results of compatibility with existing systems - Certificates proving compliance with international standards (e.g., ITU-T, IEEE, IEC)
Pre-Operation Documents	- Operation Readiness Report - Training Report	- Report confirming the system is ready for operation - Record of training sessions and participants for system operation and maintenance
Contract & Management	- Contract and Delivery Documents - Warranty Certificates - Service Level Agreement (SLA)	- Documents related to procurement, installation, and maintenance contracts - Warranty terms and conditions - Agreement on operational and maintenance quality standards (SLA)

17.6 TRAINING

The Contractor shall submit a training outline plan necessary for the operation and maintenance of the equipment. The bid price must include the costs required for the training.

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CHAPTER 18:
UNDERGROUND FIBER OPTIC (UGFO) CABLE



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CHAPTER 18: Underground Fiber Optic (UGFO) Cable

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
18.1	Preface.....	1
18.1.1	Purpose	1
18.1.2	Scope.....	1
18.1.3	Project Overview.....	1
18.1.4	Network Architecture (Network Topology)	1
18.2	General	1
18.2.1	General requirements	1
18.2.2	Applicable standards.....	1
18.2.3	Fiber Type(s) and Counts	2
18.2.4	Fiber Type(s) and Counts	2
18.2.5	Optical Fiber Cable Construction Specifications for Wet core (Type-1)	3
18.2.6	Cable drums, Marking, Packaging and Transport	7
18.2.7	Fiber Optic Link Lengths	8
18.2.8	Operating Instruction.....	8
18.2.9	Parameters of the component parts.....	8
18.3	Installation.....	9
18.3.1	Underground Fiber Optic Cable Installation	9
18.3.2	Optical Fiber Splicing	10
18.3.3	Optical Fiber Termination and Splicing.....	10
18.3.4	Optical Fiber Connectors	10
18.3.5	Service Loops	10
18.4	Inspection and Testing Requirements	11
18.4.1	Testing Requirements	12
18.4.2	Type Testing.....	12
18.4.3	Type Test Sample	13
18.4.4	Item for Type Test	13
18.4.5	Type Test for Optical Fibers	13
18.5	Factory Acceptance Tests.....	14
18.5.1	Sampling for FAT	14
18.5.2	Production Testing	15
18.5.3	Factory Acceptance Testing for Undergrounding Fiber Optic Cable.....	15
18.5.4	Site Acceptance Testing for Undergrounding Fiber Optic Cable	15



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18.1 PREFACE

18.1.1 Purpose

This specification outlines the requirements for the underground installation of optical cables for the SDH/MPLS system, including cable specifications, installation, connection methods, and terminal connections.

18.1.2 Scope

The specification covers the purchase of optical cables, junction boxes, auxiliary equipment, installation work, and testing.

18.1.3 Project Overview

Network Communication: Optical cables will be used for communication between substations and RMUs (installed on feeder lines) using SDH/MPLS communication.

18.1.4 Network Architecture (Network Topology)

A ring topology will be established between Kudhar SS and Birauta SS along the distribution lines. Each substation will have a star topology for its respective ring.

Transmission Requirements: STM-4 or STM-1 of SDH/MPLS will be used, and data from the RMUs will be collected using the IEC 870-5-104 protocol. SDH/MPLS terminal and FRTUs will be installed in the RMUs.

18.2 GENERAL

18.2.1 General requirements

This document describes the requirements of Metal free Optical fibre cable for underground installation in ducts. The cable shall have double HDPE jacketing anti-rodent & anti-termite with glass yarn in between as reinforcement. The optical fibre cable shall be suitably protected for the ingress of moisture by Flooding Jelly / WS yarn and WS tape. The raw material used in the cable shall meet the requirements as specified in the TEC GR for raw materials (GR No.TEC/GR/TX/ORM-01/04 SEP-09).

The underground fibre optic cable (UGFO) to be supplied shall be having 24/48/96 fibers count, unarmoured and shall be suitable for underground installation in pipes. The cable should be of low weight, small volume and high flexibility. The mechanical design and construction of each unit shall be inherently robust and rigid under all condition of operation, adjustment, replacement, storage and transport. UGFO shall be suitable for installation in trench and trenchless digging.

18.2.2 Applicable standards

The cable shall conform to the standards named below and the technical specifications described in the following sections.

- (a) ITU-T Recommendations G.652
- (b) Electronic Industries Association, EIA/TIA 455-78A, 455-3A, 455-62A, 455-164A/167A/174, 455-168A/169A/175A, 455-176, 455-59, EIA/TIA 598, EIA 455-104.



- (c) International Electro technical Commission standards, IEC60304, IEC60794-1-2, IEC60811-5-1.
- (d) Bellcore GR-20 with latest revision
- (e) GR/OFT-01/03. APR 2006 Tools for installation & Operating the OFC & for assembly of the OF Splice Closures.
- (f) The raw material used in the cable shall meet the requirements as specified in TEC GR: TEC/GR/TX/ORM-01/04 SEP-09 or latest amendments.
- (g) Splice Enclosure shall comply as per TEC TEC/GR/TX/OJC-002/03/APR-2010 or latest amendments, if any.

18.2.3 Fiber Type(s) and Counts

The cable shall consist of Dual Window Single Mode (DWSM) fibres conforming to G.652D and the Technical parameters stipulated in the Table –1 below:

Table 1 DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
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	$\leq 0.6\mu\text{m}$
Cladding non-circularity λ_{cc}	$\leq 1\%$
Cable Cut-off Wavelength	$\leq 1260 \text{ nm}$
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	$\geq 0.69 \text{ Gpa}$
Attenuation Coefficient:	@ 1310 nm $\leq 0.34 \text{ dB/km}$ @ 1550 nm $\leq 0.21 \text{ dB/km}$
Chromatic Dispersion; Maximum: Zero Dispersion Wavelength: Zero Dispersion Slope:	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1 300 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°C - +85°C)
Bend Performance:	@ 1310 nm (75 $\pm$ 2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB}$ @ 1550 nm (30 $\pm$ 1 mm radius Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB}$ @ 1550 nm (32 $\pm$ 0.5 mm dia Mandrel, 1 turn; Attenuation Rise $\leq 0.50 \text{ dB}$

18.2.4 Fiber Type(s) and Counts

The design and construction of Optical fibre cable shall be inherently robust and rigid under all conditions of installation, operation, adjustment, replacement, storage and transport.

- (a) The Optical fibre cable shall be able to work in a saline atmosphere and should be protected



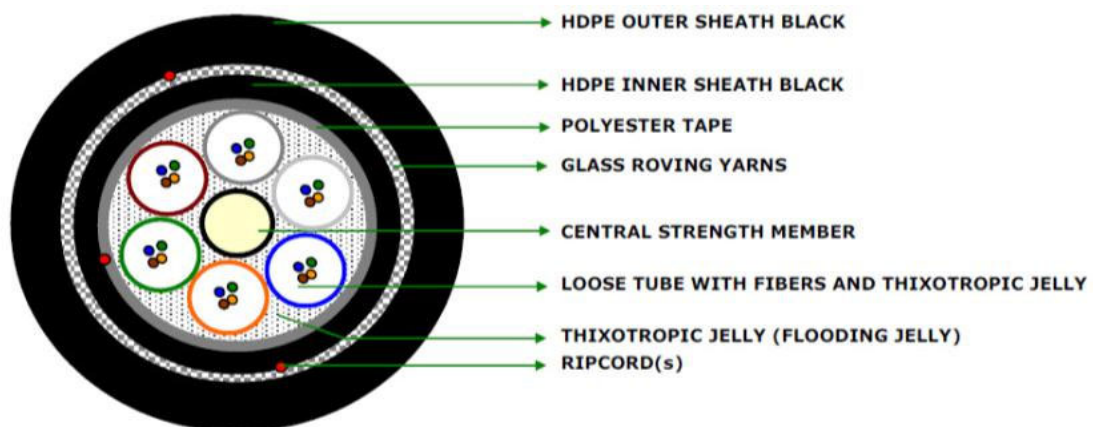
against corrosion.

- (b) Life of cable shall be at least 25 years. Necessary statistical calculations shall be submitted by the manufacturer, based upon life of the fibre and other component parts of the cable. The cable shall meet the cable aging test requirement.
- (c) It shall be possible to operate and handle the Optical fibre cable with tools as per GR No. GR/OFT-01/03 APR 2006 and subsequent amendment, if any. If any special tool is required for operating and handling the optical fibre cable, the same shall be provided along with the cable.
- (d) The Optical fibre cable supplied shall be suitable and compatible to match with the dimensions, fixing, terminating & splicing arrangement of the splice closure. The cable supplied shall also meet other requirement of splice closure (GR No.TEC/GR/TX/OJC- 002/03/APR-2010) and subsequent amendments, if any.
- (e) The manufacturer shall submit an undertaking that the optical and mechanical fibre characteristics shall not change during the lifetime of the cable against the manufacturing defects.
- (f) It is mandatory that the Optical fibre cable supplied in a particular route is manufactured from a single source of optical fibres.
- (g) The Optical fibre cable shall be manufactured so as to protect the cable from rodent and termite.

18.2.5 Optical Fiber Cable Construction Specifications for Wet core (Type-1)

General: The Metal Free optical fibre cable shall be designed to the parameters mentioned in Annexure-I. The manufacturer shall submit designed calculations and the same shall be studied and checked.

TYPICAL STRUCTURAL DRAWING FOR 24 FIBRE OF WET CORE CABLE



(1) Secondary Protection:

The primary coated fibres may be protected by loose packaging within tube, which shall be filled with thixotropic jelly. The dimensions of tube shall be in subsection (9) Supplementary Table and Drawing,

- (a) Require fiber count and requirement.
- (b) Number of fibres in cable: 24,48, 96.
- (c) Strength Member:

Solid FRP non - metallic strength member shall be used in the center of the cable core. The strength member in the cable shall be for strength and flexibility of the cable and shall have anti buckling properties. The FRP shall keep the fibre strain within permissible values.

(2) Cable Core Assembly:

Primary coated fibres in loose tubes stranded together around a central strength member using helical or reverse lay techniques shall form the cable core.

(3) Core Wrapping:

The main cable core containing fibres shall be wrapped by a layer / layers of Polyester foil/ tape. The nylon/polyester binder thread shall be used to hold the tape, if required. The core wrapping shall not adhere to the secondary fibre coating and shall not leave any kink marks over the loose tube.

(4) Moisture barrier (protection):

The main cable core (containing fibres & core wrapping) shall be protected by thixotropic flooding compound (jelly) having properties of non hygroscopic dielectric material.

(5) Filling and Flooding compound:

The filling/flooding compound used in the loose tube and in the cable core shall be compatible to fibre, secondary protection of fibre, core wrapping and other component part of the cable. The drip point shall not be lower than +70°C. The fibre movement shall not be constrained by stickiness & shall be removable easily for splicing. Reference test method to measure drop point shall be as per ASTM D 566. The thixotropic filling/flooding compound (jelly) shall be as per the GR No. TEC/GR/TX/ORM-01/04/SEP-09 and subsequent amendment issued, if any.

(6) Inner Sheath:

A non-metallic moisture barrier sheath may be applied over and above the cable core. The core shall be covered with tough weather resistant High Density Polyethylene (HDPE) sheath, black in colour (UV Stabilized) and colour shall conform to Munsell colour standards. Thickness of the sheath shall be uniform & shall not be less than 1.2 mm. The sheath shall be circular, smooth, free from pin holes, joints, mended pieces and other defects. Reference test method to measure thickness shall be as per IEC 189 para 2.2.1 and para 2.2.2.

Note: HDPE material, black in colour, from the finished cable shall be subjected to following tests (on sample basis) and shall confirm to the requirement of the material as per GR No. TEC/GR/TX/ORM-01/04 SEP.09.

- (a) Density
- (b) Melt flow index
- (c) Oxidative Induction time



- (d) Carbon black content
- (e) Carbon black dispersion
- (f) ESCR (Environmental Stress Crack T
- (g) Moisture content
- (h) Tensile strength and elongation at break
- (i) Absorption Coefficient
- (j) Brittleness Temperature

(7) Glass Reinforcement:

Impregnated Glass Fibre Reinforcement are used to achieve the required tensile strength of the optic fibre cables over the cable inner sheath to provide peripheral reinforcement along with Solid Rigid FRP Rod in the centre at cable core. These flexible strength members shall be Non-water blocking type. The use of Solid Rigid FRP Rod(s) is mandatory in Optical Fibre cable design. Impregnated Colour Coated Glass Fibre Reinforcement used shall be equally distributed over the periphery of the cable inner sheath. It shall be applied helically and shall provide full coverage to inner sheath to provide rodent protection. The quantity of the Impregnated Glass fibre Reinforcement used 20 Kg per km length of the cable along with its dimensions shall be as per Annexure-I. The specification of the glass roving shall be as per Section XII of GR No. TEC/GR/TX/ORM- 01/04 SEP.09.

(8) Outer Sheath:

A non-metallic moisture barrier sheath (black in colour) shall be applied over the inner sheath, which shall consist of tough weather resistant made High Density Polyethylene compound (HDPE) which is Anti-termite. The outer sheath shall be UV stabilized and the colour shall confirm to Munsell colour standards. The thickness of the outer sheath shall not be less than 1.6mm. The outer sheath shall be uniform, circular, smooth, free from pin holes, joints mended pieces and other defects The reference test method to measure thickness shall be as per IEC 811-5-1. Anti termite dopant shall be added in the outer sheath to resist termite attack on the cable.

Note: HDPE material from finished product shall be subjected to following tests (on sample basis) and shall confirm to the requirement of the material as per the GR no. TEC/GR/TX/ORM-01/04/SEP-09 (Section-III):

- (a) Density
- (b) Melt flow index
- (c) Oxidative Induction time
- (d) Carbon black content
- (e) Carbon black dispersion
- (f) ESCR
- (g) Moisture content
- (h) Tensile strength and elongation at break



- (i) Absorption Coefficient
- (j) Brittleness Temperature

Note: The outer jacket of HDPE shall be able to protect the cable from attack by termites.

Manufacturer shall provide the details of doping material used and same shall be verified during bulk testing. The outer sheath shall be termite protected. The surface of the sheath shall be smooth and free of defects such as cracks, blisters, etc. The cable shall be rodent protected. As specified in various clauses of the Technical specifications of the OF cable, the HDPE Outer Jacket shall be anti-termite.

(9) RIP Cord:

Three suitable ripcords shall be provided in the cable, which shall be used to open both HDPE sheath of the cable. Two ripcords shall be placed diametrically opposite each other below the outer Jacket & one ripcord shall be placed below inner sheath. It shall be capable of consistently slitting the sheath without breaking for a length of 1meter at the installation temperature. The ripcords (3ply & twisted) shall be properly waxed to avoid wicking action and shall not work as water carrier.

The ripcords used in the cable shall be readily distinguishable from any other components utilized in the cable construction.

(10) Colour coding in OF Cables

The colorant applied to individual fibres shall be readily identifiable throughout the lifetime of the cable and shall match and conform to the Munsell Colour Standards (EIA- 359-A) and also IEC Publication 304 (4).

(11) Colour Coding Scheme

When the loose tubes are placed in circular format, the marking to indicate the loose tube no. "1" shall be in blue colour followed by loose tube no.2 of orange and so on for other tubes as per the colour scheme given below and complete the circular format by placing the dummy /fillers at the end.

Depending upon the number of fibres in a loose tube (which depends on the cable capacity), the fibres are serially chosen from the column no. II of the following table-1. Last fibre in a tube shall be of natural color, while the rest of fibres are colored.

No. of Fibers/Buffer tube I	Fiber identification II	Loose tube identification III
1	Blue	Blue
2	Orange	Orange
3	Green	Green
4	Brown	Brown
5	Slate	Slate
6	White	White
7	Red	Red
8	Black	Black

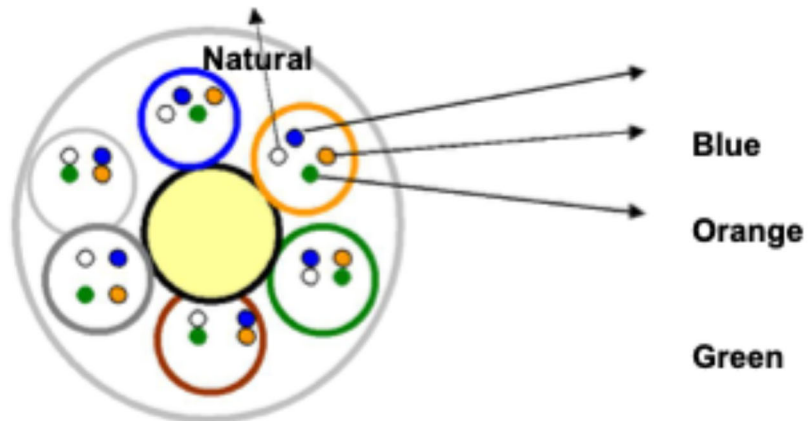


9	Yellow	Yellow
10	Violet	Violet
11	Rose/Pink	Rose/Pink
12	Natural	Aqua

Color coding of Loose Tubes (Refer Table 1) Natural

Loose Tube Colour: Blue, Orange, Green, Brown, Slate, White)

Color coding of 24 Fibres within Loose Tubes (Refer Table 1) Natural



(Fiber Colour: Blue, Orange, Green, Neutral)

18.2.6 Cable drums, Marking, Packaging and Transport

All optical fibre cable shall be supplied on strong wooden drums provided with lagging with adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. The cable drum shall be suitable to carry underground fibre optic cable of length 2 km $\pm 10\%$ (and can be customized based on the requirement). The Contractor may offer higher cable drum length in straight routes subject to transportation, handling and installation limitations. However, the exact lengths for drums to be supplied for each link shall be determined by the Contractor during detailed engineering/survey. Drum schedule shall be approved by the Employer before manufacturing the FO cable. Both cable ends in the drum shall be sealed and shall be readily accessible. The drum shall be marked with arrows to indicate the direction of rotation. Both the ends of the cable shall be provided with pulling eye. The pulling eye and its coupling system should withstand the same tensile load as applicable to the cable. The following marking shall be done on each side of the cable drums.

- Drum number
- Consignee's name and address
- Contractor's name and address Type of cable
- Number of fibres
- Type of fibres
- Year of manufacturing, month & batch no

- (g) Name of manufacturer
- (h) Total cable length
- (i) Inner end marking and Outer end marking

Packing list supplied with each drum shall have all the information provided on marking on the respective cable drum and following additional information: OTDR length measurement of each fibre and Ratio of fibre and cable length.

18.2.7 Fiber Optic Link Lengths

The fiber optic route lengths are as specified in appendices. The lengths specified in appendices are route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to loop, jointing & splicing.

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.

The payment will be made for installation on the executed route length only. Upto 3% wastages of OFC shall be allowed for specified service loops, lengths for wastage, installation/working for FO cable, joints, terminations etc during material reconciliation.

18.2.8 Operating Instruction

Complete technical literature in English with detailed cable construction diagram of various sub-component with dimensions and test data of the cable shall be provided. All aspects of installation shall also be covered in the handbook.

18.2.9 Parameters of the component parts

The following parameters of the component parts of the cable are to be taken into account while designing and manufacturing the optical fibre cables of the required fibre count. These parameters shall be checked during evaluation of the OF cables.

SN	Parameter	Unit	12 Fibre OF cable	24 Fibre OF cable	48 Fibre OF cable	96 Fibre OF cable
1	FRP rod EAA coated	mm	2.0+0.1/-0.0	2.0+0.1/-0.0	2.0+0.1/0.0	3.5+0.1/-0.0
2	Tube ID (min)	mm	1.2	1.2	1.2	1.4
3	Tube OD	mm	1.9±0.1	1.9±0.1	1.9±0.1	2.0±0.1
4	No of fore 'tube	No	4	4	8	12
5	Color of fibre		BL, OR, GR, NAT	BL, OR, GR, NAT	BL,OR, GR, BR, SL, WH, RED, NAT	BL, OR, GR, BR, SL, WH, RED, BK, YL, V, PK, NAT
6	No of loose tubes	No	3	6	6	8
7	Colour of loose tubes		BL, OR, GR	BL, OR, GR, BR, SC, WH	BL, OR, GR, BR, SL, WH	BL, OR, GR, BR, SL, WH, RD, BK
8	No or	No	3	0	0	0
9	Tube strzn•ding lay	mm	90-110	90-110	90-110	100-120
10	Inner Sheath Thickness (Min.)	mm	1.2	1.2	1.2	1.2
11	Qty of Impregnated Glass roving (Min.)	kg	20	20	20	20
12	Outer Sheath Thickness (Min.)	mm	1.6	1.6	1.6	1.6
13	Cable diameter	mm	12.8±0.5	13.2±1.0	13.2±1.0	14.5±0.5



14	Nominal cable weight	kg/km	140	140	140	175
15	Cable to be designed to Fibre strain value of	%	0.1	0.1	0.1	0.1
16	Excess fibre length	%	0.65	0.65	0.70	0.70
17	Cable to be tested at defined load for fibre strain value of	%	0.25	0.25	0.25	0.25

18.3 INSTALLATION

18.3.1 Underground Fiber Optic Cable Installation

The cable shall be installed inside one of the 40mm diameter PLB HDPE pipe installed under this package along the route(s). Generally, the cable shall be installed by compressed air blowing technique. However, for spans upto 150 meters, the Contractor can use pulling method for installation of OFC in HDPE pipe. If any temporary handhole or handhole is required for installation of OFC, the same will be done by the Contractor without any additional cost implication. Adopting pulling method for installation of OFC for spans more than 150 meter, shall be subjected to approval of the Employer and shall be substantiated by proper justification. Contractor shall take into consideration the following guidelines, for installation of OFC approval by the Employer.

- The Optical Fibre Cable Drums shall be handled with utmost care. The drum shall not be subjected to shocks by dropping etc. They shall not be normally rolled along the ground for long distance and when rolled, shall in the direction indicated by the arrow.
- The battens shall be removed only at the time of actual laying.
- A blowing machine in association with an appropriate compressor shall be used for blowing.
- Temporary blowing chambers (if required) shall be constructed and then backfilled after blowing operation is completed.
- Locations along the route, which provide easy access points for blowing machine and compressor, shall be determined.
- Before starting the cable blowing, PLB HDPE pipe shall be checked for obstacles or damage. Checking shall be done by using a proper sized mandrel.
- Always blow downhill wherever possible.
- Multiple blowing machines may be used in tandem if so required.
- Care must be taken not to violate the minimum bending radius applicable for the fibre optic cable. Tension in the cable during laying shall not exceed tension limit of the OFC.

Installation by pulling may be permitted by the Employer only in specific cases where installation by blowing is not feasible on specific approval from the Employer. In case pulling is used, the pulling speed shall be determined considering the site condition.

While installing the cable, excess length of about 10 meters shall be stored at each joint location for each side. Excess length of 10 m shall be kept at one ends of a road crossing, culvert crossing and 20 meters at one end of bridges, However, exact excess lengths and handhole locations shall be finalised during detailed engineering depending upon the site requirement.

Unit rate for installation of fibre optic cable shall interalia include all related works/activities including



associated accessories, tools & tackles, machinery etc. The BoQ in the appendices indicates the total fibre optic route length where fibre optic cable shall be installed. Accordingly, unit rate shall include all working allowances and wastages, hardware and accessories required for installation of optical fibre cable. The Owner/Employer shall not entertain any claims or payment towards installation of hardware/accessories, any additional length of cable for working allowances and wastages etc. The payment shall be made on prorata based on actual fibre optic route length executed including cable service loops/excess cable as stipulated above.

18.3.2 Optical Fiber Splicing

Splicing of the optical fibre cabling shall be minimized through careful planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur within facilities or on tower structures. All optical fibre splicing shall comply with the following:

- (a) All fibre splices shall be accomplished through fusion splicing.
- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than 12 (twelve) fibres shall be installed in each splice tray.
- (d) For each link, bi-directional attenuation of single mode fusion splices measured at 1550 nm shall not average more than 0.05 dB. The bi-directional splice loss of each splice shall not exceed 0.1 dB when measured at 1550 nm.
- (e) For in-line splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

18.3.3 Optical Fiber Termination and Splicing

Optical fibre terminations shall be done in Fibre Optic Distribution Panels (FODP) at Substations and FMS (Fibre Management System) at RMU locations. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) & FMS that shall be 1U, 2U, 3U like size and able to fit in cabinet at GO switch panel and Sub-Station FODP. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

18.3.4 Optical Fiber Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively, connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

18.3.5 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(1) Outdoor Cable Service Loops:

In-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.



(2) Indoor Cable Service Loops:

FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(3) Fibre Units Service Loops:

For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) meter of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(4) Pigtail Service Loops:

Connectorised pigtails spliced to bare fibres shall provide at least 1 meter of service loop installed in the FODP fibre organizer and at least one (1) meter of service loop to the couplings neatly stored behind the FODP coupling panels.

(5) Fibre Service Loops:

At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

18.4 INSPECTION AND TESTING REQUIREMENTS

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, production tests and other test during manufacture 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.



18.4.1 Testing Requirements

Following are the requirements of testing.

- (a) Type testing
- (b) Factory Acceptance Testing
- (c) Site Acceptance Testing

18.4.2 Type Testing

The Contractor shall submit along with their bid the earlier carried out type test reports for the offered fibre optic cable, HDPE Duct etc. meeting the requirement. The Contractor shall submit the previously carried out type test report for the same design of cable for the tests listed in this section. All items should have been type tested as per relevant standards for the tests listed in this section and the Contractor shall submit the test reports and certificates along with the bid. Type Testing shall comply with the following:

- (a) All items being supplied shall conform to type tests as per technical specification.
- (b) The reports submitted shall be of type tests conducted within below mentioned periods from the date of bid opening:

seven (7) years for UGFO, ADSS Cable and other items

In case the test reports are older than aforementioned time duration, the Contractor shall repeat these tests at no extra cost to the purchaser.

- (c) The Contractor shall submit previous type test reports. 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.
- (d) 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.
- (e) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets as per procedures provided in this technical specification. The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.
- (f) 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.
- (g) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
- (h) 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.



18.4.3 Type Test Sample

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. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

18.4.4 Item for Type Test

The type testing shall be conducted on the following items

- (a) Optical fibres
- (b) UGFO Cable
- (c) ADSS Cable (as applicable)
- (d) Splice Enclosure (Joint Box)
- (e) ADSS Fibre Optic Cable fittings (as applicable)

18.4.5 Type Test for Optical Fibers

The type tests listed below in table shall be conducted on DWDM fibres to be supplied as part of underground and overhead cables. The tests specific to the cable type are listed in this section.

Se.No	Test Name	Test Procedure
1	Attenuation	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength	IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak	IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)	IEC 60793-1-52 Or EIA/TIA 455-3A. 2 Cycle
5	Attenuation with Bending (Bend Performance)	IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field Dia	IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion	IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter	IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of Attenuation	IEC 60793-1-40 Or EIA/TIA 455-59
10	Fiber tensile Proof Testing	IEC 60793-1-20 Or EIA/TIA 455-176
11	Fiber Tensile Proof Testing	IEC 60793-1-30 Or EIA/TIA 455-31B

(1) Type Test for Underground Fiber Optic Cable

Se. No.	Test Requirement
1.	Tensile Strength Test



2.	Abrasion Test
3.	Crush Test (Compressive Test)
4.	Impact Test
5.	Repeated Bending Test
6.	Torsion Test
7.	Kink Test
8.	Cable Bend Test
9.	Temperature Cycling
10.	Cable Aging Test
11.	Water Penetration Test
12.	Test of Figure 8 (Eight) on the Cable
13.	Flexural Rigidity Test on the Optical Fiber Cable
14.	Static Bend Test
15.	Cable Jacket Yield Strength and Ultimate Elongation
16.	Embrittlement Test on loose tube Kink Resistance on loose tube
17.	Drainage Test for loose tube Drip Test on the cable
18.	Check of easy removal of sheath
19.	Check of effect of aggressive media on the cable surface (Acid and Alkaline behaviour)
20.	Termite and Rodent Test

18.5 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 UGFO Cable and associated hardware & fittings, ADSS Cable and associated hardware & fittings, Joint Box, FODP, FMS etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material 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 dispatch clearance. 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 authorized 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 tests for the supplied 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 etc.

Test equipment used for FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

18.5.1 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.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

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.

18.5.2 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), 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.

18.5.3 Factory Acceptance Testing for Undergrounding Fiber Optic Cable

The tests shall be carried out as Factory Acceptance Test for Underground fibre optic cable meeting the requirements specified in this section.

Se. No.	Factory Acceptance Test
1.	Attenuation Coefficient (1310, 1550): By EIA/TIA 455-78A or OTDR
2.	Point discontinuities of attenuation: By EIA/TIA 455-78A or OTDR
3.	Visual Material verification and dimensional checks as per approved drawings
4.	Water Penetration test
5.	Tensile strength test
6.	Impact test
7.	Kink test
8.	Environmental test (Temp Cycling Test)
9.	Crush Test

18.5.4 Site Acceptance Testing for Undergrounding Fiber Optic Cable

SAT for optical fibre cable shall be carried out link by link from FODP to FODP.

Prior to installation, every fibre optic cable segment shall be tested for continuity and attenuation and measurements shall be recorded.



Any discontinuity or attenuation beyond permissible limits in any of the fibres has to be recorded and brought to the notice of Employer.

Upon completion of a continuous cable path (FODP to FODP locations), all fibres within the cable path shall be demonstrated for acceptance of the cable path. Test requirements are indicated in table (2) below and in no case losses attributed due to other factors viz. extra splice, kinks, will be acceptable to the limit determine by the following formula:

Max attenuation @ 1550nm: $0.21\text{dB/km} + 0.05\text{dB} \times \text{total no of splices} + 0.5\text{dB} \times \text{connector}$

Max attenuation @ 1310nm: $0.35\text{dB/km} + 0.05\text{dB} \times \text{total no of Splices} + 0.5\text{dB} \times \text{connector}$

Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable failure during installation. The Contractor shall have to either replace the concerned cable span at its own cost or provide additional splicing, joint box and handholes required to rectify the fault at its own cost. The fibre attenuation shall be tested again after replacement or rectification of fault.

In case it is found that the splices are bad (loss is unacceptable as per approved test procedures), the Contractor shall have to do re-splicing and provide new Joint Box wherever required at no additional cost to the Owner/Employer. After re-splicing the end to end testing shall be repeated. The splice testing requirements are indicated in the following table.

(1) Fiber Optic Cable Pre-Installation Testing

Se. No.	Description
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm

(2) Fiber Optic Cable Splice Testing

Se. No.	Description
1.	Per splice attenuation with OTDR (bi-directional average) at 1550 nm
2.	Physical inspection of Joint Box for proper fiber routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

(3) Fiber Optic Cable Commissioning Testing

Se. No.	Description
1.	Fiber continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fiber at 1310 & 1550 nm by OTDR
2.	Fiber continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fiber at 1310 & 1550 nm by Power Meter & Laser Source
3.	Average splice loss (bi-directional) for each splice and average splice loss for the link by OTDR at 1550 nm.

CHAPTER 19:
FMS, FODP AND SPLICE ENCLOSURE



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CHAPTER 19: FMS, FODP and Splice Enclosure

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
19.1	Fiber Management System (FMS).....	1
19.1.1	General	1
19.1.2	Patch Cords	1
19.1.3	Factory Acceptance Test for FMS	1
19.1.4	Site Acceptance Test for FMS	1
19.2	Joint Box	1
19.2.1	Joint Box (Splice Enclosure) and Splicing	1
19.2.2	Methodology for Splicing at RMU locations	2
19.2.3	Cable Entry and Sealing Arrangements	2
19.2.4	Holding Arrangements	2
19.2.5	Compatibility	3
19.2.6	Marking on body of the Joint Box.....	3
19.2.7	Type Tests for Joint Box.....	3
19.2.8	Factory Acceptance Tests for Joint Box	4
19.2.9	Site Acceptance Tests for Joint Box	4
19.3	Fiber Optic Distribution Panel (FODP)	4
19.3.1	Optical Fiber Connectors	4
19.3.2	Optical Fiber Splices	5
19.3.3	Factory Acceptance Test for FODP.....	5
19.3.4	Site Acceptance Test for FODP	5
19.4	Splicing of Fibers in Existing Joint Box or FODP	5
19.5	Service Loops	5



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19.1 FIBER MANAGEMENT SYSTEM (FMS)

19.1.1 General

Fibre Management System (FMS) or Line Interface Unit (LIU) shall be used at RMU & GO switch locations. These FMS shall be used to connect fibre optic cable from Manhole / Splice enclosure to the communication equipment.

Indoor FMS Shall be 1U/2U/3U/4U size and rack mountable through sliding into panel. It shall be as per relevant TEC GR. Outdoor FMS shall be wall mountable or shall be mountable to Ground/Footpath. Outdoor FMS shall also conform to IP68 protection and latest TEC GR.

Indoor type FMS shall be installed into the existing Cabinet/Panel of RMU panel. However, for outdoor FMS cabinet to be provided along with cabinet and locking arrangement.

TEC GR Reference: GR/FDM-01/02/APR-2007 (Type-I) with latest amendment No. TEC/T/OFC-FDMS/149/2012.

FMS should have following features:

- (a) Metal base material with powder coating for light mounting.
- (b) Connectivity available for all type of connector available e.g. SC, LC, FC, ST, E2000 Terminations. There should be arrangement of termination of 96/48/24/12/6 Nos. of fibers
- (c) It should be mountable in standard 19" rack and of slider type.
- (d) Shall supplied with all accessories e.g. Cable Ties, mounting ear screw, sleeves, Tissue, Fiber cleaner liquid etc.

The FMS shall be manufactured as per latest state of art technology. Body should be of MS steel; powder coating painting (min. 70 micrometer thickness) shall be provided with rust resistance paint.

19.1.2 Patch Cords

The Patch cords should be confirming to TEC NO.: TEC/GR/TX OFJ-01/05/NOV-09 with latest amendment No. TEC/T/OFC-OFJ/155/2013.

19.1.3 Factory Acceptance Test for FMS

Visual check of Quantities and Specific Component Number for each component of FMS and dimensional checks against the approved drawings.

19.1.4 Site Acceptance Test for FMS

Site Acceptance Tests for FODP shall be done as per the direction of Employer.

19.2 JOINT BOX

19.2.1 Joint Box (Splice Enclosure) and Splicing

The UGFO and ADSS cables would be required to be spliced at every joint, normally at a distance of every 2 km. Splicing to be for underground cable at Manhole and for ADSS cable on the 11 kV poles. For the ADSS Joint Box, pole mounting structure to be provided along with joint box. Joint box shall be as per TEC GR TEC/GR/TX/OJC-002/03/APR-2010 or latest amendments, if any. Joint



Box shall be universal type that can be placed on underground and overhead locations.

Joint Box shall be suitable to both straight joint and branch joints. Maximum 12 fibres shall be splices in one splice tray. In the Price Schedule different type of joint box mentioned 12F, 24F and 96F. 12F & 24F Joint Box shall be used for branch joints and for straight joint between branching cables. For the joint between UGFO and ADSS it will be done preferably on O/H (on the poles).

Manhole shall be placed at around 200m for installation/pulling of UGFO. At these manholes where splicing is not to be done UGFO cable shall kept with 15 meter additional loop for future Telecom purpose.

19.2.2 Methodology for Splicing at RMU locations

96F UGFO and ADSS shall be used as main feeder FO cable and 12F & 24F cable (UGFO/ADSS) shall be used as branching cable to connect 6 fibres from main 96F to FMS.

At RMU / GO switch location, 6 fibre from 1 tube of UGFO /ADSS cable of multitube cable shall be cut and spliced inside joint box and other tubes shall be bypassed to save splice losses of remaining fibres. At the location where UGFO/ADSS drum to be terminated, all the 96Fibers shall be spliced. The methodology in this regard shall be finalized during detailed engineering.

19.2.3 Cable Entry and Sealing Arrangements

The base shall have a minimum 4 single cable entry ports and one port for express (looped) cable entry. The arrangement shall be provided for terminating looped or express cable by making a suitable necessary provision. All ports shall be sealed, and entry ports (sealed) shall be opened as per the requirement. The opening of any port shall not cause any interference to any existing cable. No heat shrink of any type shall be allowed on the cable for sealing. No screws or nut & bolts of any type shall be allowed. The sealing material shall be termite proof.

No consumable items shall be required for sealing. The sealing components must be reusable and shall have unlimited shelf life. The sealing arrangements shall be specified along with opening and closing arrangement by the manufacturer and the same shall be tested.

It shall be possible to terminate all cables having outer diameter of 20mm (Max.).

The joint enclosures shall contain fibre organizer system where the extra length of fibres and splices are stored in systematic & secured manner. The method or device for safely routing and securing buffer tube and bare fibre shall be provided.

The joint enclosures shall allow an easy opening and re-closing without degradation in the performance of joint enclosure. Access to the inner junctions shall be possible without damaging the existing cables. The closure must be designed such that no installed cable is disturbed or require re-sealing of the existing cables during installation of additional cables.

19.2.4 Holding Arrangements

The box shall provide the following:

- (a) Holding arrangement and framework for properly securing cable organizers with splice trays.
- (b) Securing arrangement for holding fibres.
- (c) Holding device to hold strength member of fibre optic cable securely.



- (d) Any other extra component required for providing strength and reliability to the Joint Box.

19.2.5 Compatibility

All the component and parts used shall be compatible with the optical fibre cable, fibre splices and cable components. Their use for long should not result in increase in transmission loss or deterioration in other properties.

19.2.6 Marking on body of the Joint Box

The following information by marking on Joint box shall be provided:

- (a) Manufacturer's name & date
- (b) Type of Joint box
- (c) Number of Splice organiser cassettes
- (d) Number of splices per cassette
- (e) Batch number and serial number.

19.2.7 Type Tests for Joint Box

The Joint Box offered to be supplied should have been type tested as per requirement specified in TEC/GR/TX/OJC-002/03 APR-10 with latest revisions or equivalent standard. The Contractor shall submit the earlier carried out type test reports for the offered joint box meeting the requirement.

List of type tests on joint box are given below:

- (a) Water Ingress Test.
- (b) Drop and Topple Test.
- (c) Air Tightness Test.
- (d) Static Load Test.
- (e) Impact Test.
- (f) Vibration Test.
- (g) Environmental Cycle Test.
- (h) Salt Spray (Mist) Test.
- (i) Resistance to Aggressive Media Test.
- (j) Resistance to Stress Cracking Test.
- (k) Variation in Attenuation.
- (l) Torsion Test.
- (m) Flexure Test.
- (n) Clamping Test.
- (o) Thermal Aging.



- (p) Current Surge Test.
- (q) UV Test.

19.2.8 Factory Acceptance Tests for Joint Box

Se. No.	Name of Test
1.	Visual Inspection
2.	Tightness (Sealing) Test
3.	Static Load Test
4.	Impact Test
5.	Axial Pull Out Test
6.	Bending Test
7.	Water Ingress Test
8.	Reopening Test

19.2.9 Site Acceptance Tests for Joint Box

All the joint boxes shall be physically inspected (visual) tightness checking of clamps and bolts, heat shrink sleeves and proper installation in the manholes. In case the Employer finds the workmanship of the installation of joint box to be poor, the Contractor shall make good the same. Consumable, if any e.g. joint box sealing, heat shrink sleeves, required for rectification work shall be provide by the Contractor at no extra cost to Employer/Owner.

19.3 FIBER OPTIC DISTRIBUTION PANEL (FODP)

This section describes the general requirements, type and factory testing requirements of Joint Box for underground optical fibre cables. At locations requiring the termination of at least one pair fibre within a cable, all fibres within that cable shall be connectorised and terminated in FODPs in a manner consistent with the following.

- (a) FODP shall be provided to accommodate rack mountable 1U (24F) & 2U (48F) FODP Subrack with Splicing & Patching Trays, with suitable patch cord & Adaptors in 2200x600x600 Cabinet.
- (b) All fibre optic terminations shall be housed using FODPs provisioned with splice organisers and splice trays. All fibres within a cable shall be fusion spliced to preconnectorised pigtails and fitted to the backside of the provided couplings. The pigtails and the fibres shall be stored and dressed neatly in the provided trays and holders. The pigtails/fibres shall be numbered using suitable ferrules.
- (c) Ground lugs shall be provided on all FODPs and the Contractor shall properly ground all FODPs. The FODPs shall be properly fixed/grouted to the floor and or with wall with better support. Necessary installation material for fixing the FODP on wall or ground shall be provided by the Contractor.
- (d) The location of FODPs rack shall be fixed by the Contractor, with the Employer's approval.
- (e) Flexible protection shall be provided to the patch cord bunches going out from FODP to another equipment.

19.3.1 Optical Fiber Connectors

FC-PC type connectors shall be used. Average loss of the FC-PC connectors shall not exceed 0.5dB.



19.3.2 Optical Fiber Splices

Splicing of the optical fibre cabling shall be minimized through careful planning. It is important that all splicing work be done under clean conditions. All required splices shall be planned to occur at Joint location/manhole. All optical fibre splicing shall comply with the following:

- (a) All fibre splices shall be accomplished through fusion splicing.
- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) For splicing of each fibre, every effort shall be made to minimise the bidirectional average splice loss.
- (d) All splices and bare fibre shall be neatly installed in covered splice trays.
- (e) Average bi-directional splice loss at any particular splice shall not exceed 0.1dB but total bi-directional average of all splices in a link shall not exceed 0.05dB.
- (f) Fibre optic cable service loops as indicated in technical specifications shall be provided.

19.3.3 Factory Acceptance Test for FODP

Visual check of Quantities and Specific Component Number for each component of FODP and dimensional checks against the approved drawings.

19.3.4 Site Acceptance Test for FODP

Site Acceptance Tests for FODP shall be done as per the direction of Employer.

19.4 SPLICING OF FIBERS IN EXISTING JOINT BOX OR FODP

In case it is required to do re-splicing for rectification or splice new cable in an existing Joint Box, above stipulations for splicing shall be applicable. In such conditions, splicing of only few fibres of the existing cables in the Joint Box with the new cable shall be done. For working in existing Join Box/FODP, the Contractor shall take due care so that the traffic in the balance fibres is not affected.

19.5 SERVICE LOOPS

For purposes of this specification, cable and fibre service loops are defined as slack (excess) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable system.

(1) Outdoor Cable Service Loops:

At manhole chambers splices are installed with sufficient fibre optic cable service loops (as mentioned in Technical Specification) such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level. Optical cable service loops (excess cable) shall also be provided at all crossings in manholes (as mentioned in Technical Specification).

(2) Indoor Cable Service Loops:

At FODPs, Contractor shall provide at least three (3) metres of cable service loop. Service loops



shall be neatly secured and stored, coiled such that the minimum recommended bend radius is maintained.

(3) Fiber Units Service Loops:

For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(4) Pigtail Service Loops:

Connectorised pigtails spliced to bare fibres shall provide at least 0.5 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(5) Fiber Service Loops:

At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

CHAPTER 20: **METERING ARRANGEMENT**



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CHAPTER 20: Metering Arrangement

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
20.1	GPRS-based Modem.....	1
20.1.1	Requirements	1
20.1.2	General Features	1
20.1.3	Modem Functionality	1
20.1.4	Power Supply.....	2
20.1.5	GSM/GPRS section	2
20.1.6	SIM Card Section.....	2
20.1.7	Communication Interface & Capabilities	2
20.1.8	RF Section	2
20.1.9	Network Identification.....	3
20.1.10	Data Features for GSM/GPRS module	3
20.1.11	EMI/EMC Specifications	3
20.1.12	Mechanical Specifications.....	3
20.1.13	Environmental Specifications (Operating Conditions).....	3
20.1.14	Functional Specifications (Operating Features)	3
20.2	Metering Arrangement from Air Circuit Breaker (ACB) (NOt applicable)	4
20.3	Metering Arrangement from Multi-function Meter (MFM)	4
20.4	Inter-Branch/Inter-Substation metering Unit Arrangements	5
20.4.1	Scope.....	5
20.4.2	Design.....	5
20.4.3	Current Transformers.....	5
20.4.4	Voltage Transformers.....	6
20.4.5	Terminal Markings of CT's and VT's	6
20.4.6	Rating Plates of CT's and VT's	7
20.4.7	Secondary Wiring.....	7
20.4.8	Type Test	7
20.4.9	Completeness of Equipment.....	8



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20.1 GPRS-BASED MODEM

20.1.1 Requirements

The GPRS modem shall be installed inside the RMU or LP (Low tension Pillar) and used to transmit the energy data (Wh) and other electrical parameters measured by the Multi-Function Meter (MFM) of the distribution transformer to the Data Concentrator Unit (DCU).

20.1.2 General Features

- (1) Measurement Signals
 - (a) Phase currents
 - (b) Voltage (phase-phase, phase-neutral)
 - (c) Power (active, reactive, apparent)
 - (d) Power factor
 - (e) Frequency
 - (f) Import/Export Energy (active, reactive, apparent)

20.1.3 Modem Functionality

- (1) Data Collection
 - (a) Complete meter data stored in the meter (hourly, daily, weekly, monthly)
 - (b) Instantaneous parameters at the time of reading
 - (c) Billing data, present & last 12 months histories
 - (d) Load survey (30 days or complete number of days stored)
 - (e) Tamper data, settings/configuration data-
 - (f) Instantaneous parameters (every 15/30/60 minutes or daily)
- (2) Communication and Interface
 - (a) Connected to an electronic meter via optical/RS232 port
 - (b) Compatible with all energy meters including DLMS meters
 - (c) Auto restart with built-in watchdog timers
 - (d) On-line tamper detection with SMS alerts
 - (e) Program Over The Air (POTA) feature for remote firmware updates
 - (f) Remote start/stop and restart
 - (g) Auto recover feature in case of modem/network hanging
 - (h) Comprehensive self-diagnosis with log creation
 - (i) Real-time outages and alarms as alerts



- (j) Automatic GPRS connection without AT commands
- (k) Inbuilt three-phase power supply and operational on single phase
- (l) Automatic pushing of meter data at regular intervals
- (m) IP-based communication for simultaneous data access
- (n) Configuration over the air feature for GPRS MODEM operational settings
- (o) Configurable scheduled meter read and data transmit feature
- (p) Selective on-demand meter read feature

20.1.4 Power Supply

- (a) Operating on three-phase supply (77 AC P-P to 470V AC P-P, 50 Hz) and single-phase 230V, 50 Hz power supply
- (b) Surge protection according to Indian conditions (6.0 kV)
- (c) Power consumption not more than 3.5VA

20.1.5 GSM/GPRS section

- (a) Dual Band GSM 900/1800 MHz compliant with ETSI GSM Phase 2+ Standard
- (b) Supports Point-to-Point transmission and Cell Broadcast features
- (c) Supports data and SMS transmission

20.1.6 SIM Card Section

- (a) SIM Card Holder accessible by opening/sliding the cover
- (b) Supports 1.8V/3V Interface
- (c) Sealed cover to prevent unauthorized access

20.1.7 Communication Interface & Capabilities

- (1) RS232 Serial Link
 - (a) Supports up to 115,200 bauds with auto-banding option
 - (b) 9-pin female/RJ11 connector for electronic energy meter's optical/serial communication port
 - (c) Pre-configured for meter reading and data transfer
- (2) RS485 Serial Link
 - (a) Supports up to 115,200 bauds with auto-banding option
 - (b) Pre-configured for meter reading and data transfer

20.1.8 RF Section

- (1) Antenna Interface



- (a) SMA interface for fixed or wired (with magnetic base) Dual Band built-in Antenna with minimum -6dbi gain
- (b) Provision to connect 14dbi high gain external antenna

20.1.9 Network Identification

- (a) Status LED indicates current functioning status (power up, registered in network, transmitting data)

20.1.10 Data Features for GSM/GPRS module

- (a) TCP, UDP, HTTP, FTP
- (b) GPRS Class B Multi-slot class 12 or 10

20.1.11 EMI/EMC Specifications

- (a) Electrostatic Discharge (IEC61000-4-2)
- (b) Fast Transient Burst (IEC61000-4-4)
- (c) Surges Immunity (IEC61000-4-5)
- (d) Conducted Emission (CISPR22 class B)

20.1.12 Mechanical Specifications

- (a) Compact, Polycarbonate/engineering plastic enclosure
- (b) Easy mounting arrangement with a hook and screw fixing
- (c) Sealing arrangement to prevent tampering

20.1.13 Environmental Specifications (Operating Conditions)

- (a) Temperature: -10°C to +55°C
- (b) Humidity: up to 95% RH (non-condensing)

20.1.14 Functional Specifications (Operating Features)

- (a) Long-duration data transfer to central station
- (b) IP55 rating
- (c) Power outage notification with alerts
- (d) Continuous operation under field conditions
- (e) Auto-Scheduler for automatic data collection during night hours
- (f) Configurable data transfer modes (push and pull)
- (g) Provision for flexible scheduling of meter readings



20.2 METERING ARRANGEMENT FROM AIR CIRCUIT BREAKER (ACB) (NOT APPLICABLE)

A, B and C type Low Tension Distribution Board (LT DB) equipped with microprocessor-based Air Circuit Breaker (ACB) will be installed adjacent to the distribution transformer (DT) for necessary protection, control and measurement purposes. Micro-processor based ACB shall be compatible for integration with the smart meter server and/or DCC with the help of GPRS or Radio modem or with the help of FRTU and MPLS Equipment over the optical fiber channel. Interface equipment (as applicable) and necessary software shall be supplied by the Contractor at no extra cost. The measurement signal from the ACB shall include but not limited to the followings:

- (a) Phase currents
- (b) Voltages (phase-phase, phase-neutral)
- (c) Power (active, reactive, apparent)
- (d) Power factor
- (e) Frequency
- (f) Import/Export Energy (active, reactive, apparent)

20.3 METERING ARRANGEMENT FROM MULTI-FUNCTION METER (MFM)

D1 and D2 type Low Tension Distribution Board (LT DB) shall be supplied with CTs and multifunction meter (MFM) of 0.5S accuracy along with all required accessories for the purpose of metering and will be installed adjacent to the distribution transformer (DT) for measurement purpose. Multifunction meter shall be compatible for integration with the smart meter server and/or DCC with the help of GPRS or Radio modem or with the help of FRTU and MPLS Equipment over the optical fiber channel. Interface equipment (as applicable) and necessary software shall be supplied by the Contractor at no extra cost. The measurement signal from the Multifunction meter shall include but not limited to the followings:

- (a) Phase currents
- (b) Voltage (phase-phase, phase-neutral)
- (c) Power (active, reactive, apparent)
- (d) Power factor
- (e) Frequency
- (f) Import/Export Energy (active, reactive, apparent)

Sl.No.	Item	Requirement
1	Application	DT(Distribution Transformer) Metering
2	Rated Voltage	240 V (Phase to neutral)
3	Rated Current	I basic: 5 A, I max:10 A
4	Frequency	50 Hz +/-5%
5	Overload Capacity	200% of Ibasic
6	Minimum starting current in % of base current	0.1 %
7	Power Factor	0.0 Lag-Unity-0.0 Lead
8	Accuracy Class	0.5s



9	Working range for Voltage	V ref +20% to -40%
10	Applicable Standard	IS 14697, IS15959, IEC62053,
11	Sampling Interval Period	15/30/60 minutes
12	Battery Life of RTC Battery	10 years
13	Type of Output Device	LED Pulse Output
14	Dust and Ingress Protection	IP-51
15	Total number of Events	More than 200
16	Billing Data History Availability	More than 12 months
17	Spark Immunity	35 kV
18	Communication Port	Optical as per IEC1107 and Additional RS232 port in RJ11 for Remote communication

20.4 INTER-BRANCH/INTER-SUBSTATION METERING UNIT ARRANGEMENTS

20.4.1 Scope

- (a) Inter-branch metering unit (CT, PT, Control cable, Energy meter box etc.) installation at 11kV voltage system and integration of data to the smart energy meter server and/or Distribution Control Centre (DCC);
- (b) Inter-substation metering unit (CT, PT, Control cable, Energy meter box etc.) installation at 11kV voltage system for ring network formation and integration of data to the smart energy meter server and/or DCC;

20.4.2 Design

Metering units shall be suitable for direct connection to adjacent extensible switch disconnectors and fuse-switches or circuit breaker RMUs or on the poles.

This shall include a sealed and lockable enclosure that may be safely accessed. The bottom of the enclosure shall be located between 1.0 to 1.5 meter above ground level for easy access to secondary terminations during commissioning and testing.

Only metering components and terminations as specified below shall be contained inside the enclosure. An earth stud shall be provided within the enclosure for connection to the earth system.

The metering unit design and construction shall facilitate the replacement of CT's and VT's in situ. The design shall also be such that all internal bus bars lengths between CT's and VT's are minimized.

The Vendor shall submit with the Proposal, dimensioned outline drawings, schematic, layout and wiring diagrams of the metering units for review by owner/consultant during detailed engineering.

20.4.3 Current Transformers

Three current transformers (CT) of single core shall be provided with ratio 400-200/1 A for 11 kV metering units of Class 0.5 M to AS 60044.1-2007, 15 VA output at unity burden. Current ratio may be changed as per requirement during detailed engineering.

Accuracy requirements for both directions of current flow (P1 to P2 and P2 to P1), must be met at the marshalling enclosure terminals.

One CT shall be connected in each of the three phases and shall comply in all respects with AS



60044.1-2007. The current ratio change shall be made by tapped secondary with all ratios brought out to the metering terminal block within the marshalling enclosure.

The CT terminal box shall have provision for sealing facilities.

20.4.4 Voltage Transformers

One three-phase or 3 single-phase voltage transformer(s) (VTs) shall be provided of ratio:

- (a) $11/\sqrt{3}$ kV: $415/\sqrt{3}$ V for 11 kV, and
- (b) 15 VA per phase, star/star connected, and
- (c) Class 0.5 M, and
- (d) Uniformly insulated secondary star point brought out and terminated in the metering cubicle.

It is important to note that all secondary earthing points on the VT's shall be removed from inside the cubicle and terminated on the metering terminal block.

The accuracy requirement must be met at the marshalling enclosure terminals.

The voltage transformer must be suitable for operation with the high voltage star point connected to ground. The rated voltage factor shall be determined in accordance with AS 60044.2-2007. The voltage transformer(s) shall comply in all respects with AS 60044.2-2007. The VT terminal box shall have provision for sealing facilities.

20.4.5 Terminal Markings of CT's and VT's

The following terminal markings are required and shall be clearly and indelibly marked or engraved and must be clearly visible from inside the MV chamber:

- (1) Voltage Transformers (VT)
 - (a) Primary Winding:
 - (i) 'A, N' for Red Phase
 - (ii) 'B, N' for White Phase
 - (iii) 'C, N' for Blue Phase
 - (b) Secondary Winding:
 - (i) 'a, n' for Red Phase
 - (ii) 'b, n' for White Phase
 - (iii) 'c, n' for Blue Phase
 - (c) Phasing

Ensure that when 'A' is positive with respect to 'N', 'a' is positive with respect to 'n' and similarly for 'B' and 'C'.

NOTE: Where 3 x single-phase electromagnetic VT's are star- connected, the terminals 'N' and 'n' form the primary and secondary star points respectively.



(2) Current Transformer (CT)

(a) Primary Winding:

P1 to P2 in the normal direction of current flow

(b) Secondary Winding:

s1, s2, s3 - The polarity shall be arranged so that current flow into terminal P1 induces current flow out of terminal s1.

- (3) Labels P1 and P2 are to be placed inside the adjacent marshalling cubicle walls to indicate the orientation of Primary Current flow in the CT's with relation to the RMU housing.

20.4.6 Rating Plates of CT's and VT's

Rating plates shall be permanently attached to the CT's and VT's and copies of these labels shall be securely attached to the inside of the metering cubicle and shall be clearly visible while in service. The markings on these plates shall comply fully with the requirements of AS 60044.1-2007 and AS 60044.2-2007 respectively.

20.4.7 Secondary Wiring

All secondary wiring within the metering unit shall be 2.5 mm² cable which shall be supplied along with the metering unit. VT and CT secondary terminations shall be wired out from their respective terminal boxes to the marshalling enclosure, which is to be provided along with the metering unit, in their respective colors for the individual phases they represent. The S1 terminals from the three CT's shall be earthed locally to the main earth bar.

Wire identification shall be with white wire marking ferrules with engraved letters and numerals filled with non-deteriorating black paint. Ferrules shall be mounted as close as practicable to the termination point at both ends of the wire and assembled so that they may be read right-way-up from the normal viewing position.

Wiring must be installed such that it cannot suffer damage from stretching, pinching, fatigue or accidental interference during normal operation or maintenance. Mechanical barriers or protection shall be installed to prevent such wire damage.

The marshalling enclosure shall be accessible at all times while the bus bars are live and have provision for sealing and locking the enclosure.

The marshalling enclosure provided with the metering unit shall be located within the metering cubicle provided by the Vendor.

The secondary terminal box shall have cable gland/ flange suitable to receive control cables of suitable size at the bottom of the secondary box for metering connections to secondary winding of 11 KV CT PT unit.

20.4.8 Type Test

Certified copies of all type tests as per IS-2705-1992, IS: 156-1992 with latest amendments, listed below obtained from any accredited test laboratory on similar equipment included in this specification shall be furnished:

- (a) Short Time Current Test.



- (b) Lightning Impulse voltage withstand Test.
- (c) Temperature Rise Test.
- (d) Wet Power Frequency Voltage Withstand Test.
- (e) Determination of Errors according to the requirement of the appropriate Accuracy Class.
- (f) Instrument Security Factor Test.

20.4.9 Completeness of Equipment

Any fittings, accessories or apparatus which may not have been specifically mentioned in the specification, but which are usual or necessary in the equipment of similar type shall be deemed to be included in the contract and shall be supplied by the Contractor without extra charges.



CHAPTER 21:

CIVIL WORKS



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CHAPTER 21: Civil Works

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
21.1	Site Works	1
21.1.1	Work included	1
21.2	Laying of underground cable	1
21.2.1	Work included	1
21.3	Foundation Design	1
21.3.1	General	1
21.3.2	Submittal	1
21.3.3	Design Load	1
21.3.4	Uplift and Overturning Loads	1
21.3.5	Unit weight for overturning resistance	2
21.3.6	Foundation type	2
21.3.7	Soil test	2
21.3.8	Typical Soil Investigation Report	3
21.4	Excavation	4
21.5	Backfill	5
21.6	Road Pavement	5
21.6.1	General Requirements	5
21.6.2	Road Restoration	6
21.7	Timber shoring	6
21.8	Select borrow	7
21.9	Permission	7
21.10	Foundation Construction	8
21.10.1	General requirements	8
21.10.2	Reference to standard specifications	8
21.10.3	Concrete	8



21.10.4	Construction Materials	9
21.10.5	Storage of materials	9
21.10.6	Concrete Mixing	9
21.10.7	Concrete Testing	10
21.10.8	Concrete Formwork	11
21.10.9	Concrete Finishing and curing	11
21.10.10	Membrane curing compound	12
21.10.11	HYSD/TMT reinforcing bar	12
21.10.12	Grouting	12
21.11	Foundation Protection Works	13
21.11.1	Stone Masonry Works	13
21.11.2	Gabion Wall	13
21.12	FQP: Field Quality Plan	14
21.13	Interfacing	14
21.14	Site Acceptance Test for Excavation, Backfilling, Installation, Manholes	14



21.1 SITE WORKS

21.1.1 Work included

Furnishing all materials, equipment and labor and performing all operations required for enhancement of distribution network indicated on the drawings, specified herein and as evidently necessary to complete the work as given in the price schedule.

21.2 LAYING OF UNDERGROUND CABLE

Contractor shall execute all construction work for under grounding of 11 kV and 400/230V cables. This work shall include all kinds of civil works complete in all respects as per relevant codes and drawings.

21.2.1 Work included

Furnishing all materials, equipment and labour and perform all operations required for the design and construction of all the concrete foundations for equipment and other structures, underground containment and cable trenches, as specified herein and as evidently necessary to complete the work.

21.3 FOUNDATION DESIGN

21.3.1 General

The Contractor shall design all foundations required for completion of the project and as per the site requirement. The design shall be based on the recommendation of soil test report by soil consultant. In case of urgency, the design and drawings may be taken up with assumed soil parameters and after completion of the soil testing necessary modifications may need to be taken care. There can be multiple varieties of foundations for the same equipment based on the recommended soil investigation report and existing underground services.

21.3.2 Submittal

The Contractor shall submit all the design calculations, detail drawings and reinforcement steel schedules to the Owner/Engineer for review and comment before construction commences. Review of the foundation design by the Owner/Engineer in no way relieves the Contractor of his responsibility for an adequate foundation design, even though this Specification sets forth the basis foundation design criteria. Upon receiving the Owner's /Engineer comments, the Contractor shall submit to the Owner/ Engineer final drawings of all foundation details, including reinforcement steel schedules on drawing sheet sizes for record file.

21.3.3 Design Load

The structure design loads are defined on the structure outline drawings and the loads used to design the foundation shall be actual working loads applied to the foundations by the equipment and structures. The foundations shall be designed to resist all vertical and lateral forces, uplift forces and overturning moments with a minimum factor of safety of 1.5.

21.3.4 Uplift and Overturning Loads

The uplift and overturning resistance of concrete spread footing shall be assumed as the weight of



a volume of earth in the form of an inverted frustum of cone or pyramid. The cone or pyramid height shall be 30cm less than the depth from finish grade to the top of the concrete mat, the base area shall be the top area of the mat and the top area shall be determined by the intersection of planes starting at the mat edges and sloping outward at a 20 degree cone angle from the vertical and the horizontal plane 30 cm below finish grade.

21.3.5 Unit weight for overturning resistance

The following unit weight shall be used for design:

- (a) Soil..... 1,200 kg/m³
- (b) Concrete 1,600 kg/m³

21.3.6 Foundation type

In the presence of high-water table, the foundation shall be designed for a maximum depth of 1.5 meter below the existing ground level. The foundation is to be designed for fully submerged condition.

21.3.7 Soil test

The Contractor shall carry out soil tests to determine the ground bearing capacity by means of a Standard Penetrations Test and Auger Boring and tests shall be performed as per BS/IS/Equivalent international standards.

- (a) The Contractor shall perform soil investigation work according to the approved location plan preferably nearer to the Supporting Structures around the river crossing or RMU or as decided by the site in charge. Report on test results including various data collected during the investigation works and Contractor's recommendations, on which the design will be based, shall be approved by the Employer/Engineer.
- (b) For the river crossing point, drilling of bore holes in accordance with the provisions of BS/IS/Equivalent standards up to 10 m depth or to refusal which ever occur earlier. However, in case deep pile foundations are envisaged the depths have to be regulated as per codal provisions. In cases where rock is encountered, coring in one borehole per bay shall be carried out to 1.5 m in bedrock and continuous core recovery is achieved.
- (c) Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 0.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Collecting undisturbed samples of 100/75 mm diameter 450 mm long from the boreholes at intervals of 2.5 m and every change of stratum starting from 1.0 m below ground level onwards in clayey strata.
- (d) The depth of Water table shall be recorded in each borehole.
- (e) All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.
- (f) 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 laboratory without any damage or loss.



- (g) The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-charge.
- (h) The Contractor shall provide all necessary equipment, materials and personnel to prepare conduct and report the tests.

21.3.8 Typical Soil Investigation Report

Typical soil Investigation report shall include but not limited to the following:

- (1) Cover Page
 - (a) Name of the Project
 - (b) Report document No. & revision
 - (c) Name of Soil consultant agency, e-mail address, telephone number. Etc.
 - (d) Report shall be duly signed & stamped by Soil consultant & Vendor.
- (2) Index
 - (a) Page No. & Description
- (3) Introduction
 - (a) Scope of the work
 - (b) Accessibility of the site
 - (c) Location of the site including colour copy of google maps & global coordinates.
- (4) Field Investigation
 - (a) Water table
 - (b) Water table in rainy season
 - (c) Chemical Nature of soil & ground water
 - (d) Deleterious effects of soil & ground water, if any.
- (5) Laboratory Test
 - (a) All the Lab-test shall be conducted as mentioned in TS-civil works over the undisturbed sample and disturbed sample
 - (b) Drained & Undrained Tri-axial Test shall be conducted as per the site condition.
 - (c) Laboratory test results indicating bore hole No. depth wise.
 - (d) Laboratory test shall be conducted in NEA approved lab & min 5 % test shall be witnessed by NEA / Consultant.
- (6) Bearing Capacity Calculation
 - (a) By Shear & settlement Criteria.



- (b) Bearing Capacity shall be calculated by analytical method (BIS code & SPT No.)
- (c) Min FOS 2.5 shall be taken. Allowable Settlement shall be as per relevant IS code for soil type and building type.
- (d) In rocky strata, type of foundation & recommendation regarding Rock anchoring.
- (7) Observation & Recommendations
 - (a) Bearing capacity table for various footing size (Isolated & Raft) starting from 0.5 m depth below EGL up to 3 m depth i.e. 0.5 m, 1.0 m, 1.5 m & so on.
 - (b) Recommendation of footing type for various types of structures.
- (8) Soil Improvement Technique
 - (a) In case of low bearing capacity, soil improvement technique for various types of structures shall be proposed with supporting calculation & necessary tests.
 - (b) In case of black cotton soil, consultant should give their recommendations for soil improvement.
 - (c) In case of Pile foundation, different dia. & depth (Min 02 options) of pile shall be suggested for minor & major structures of the H-structure poles.
- (9) Annexure
 - (a) Mohr Circle graph, Bore Hole Log profile depth wise, Laboratory test summarized strata wise, Time Vs Settlement chart, Grain size analysis, results of the lab test.
 - (b) Plan showing the location of exploration work
 - (c) Sample calculation clearly showing the formula and Values.

21.4 EXCAVATION

The Contractor shall excavate earth, rock, stumps and all the other materials encountered as required for construction of the foundations, underground containments and trenches. The Contractor shall place all suitable excavated materials in backfill or in graded embankment in the immediate area at structures. Materials found to be unsuitable for foundation backfill or grading shall be wasted and disposed off at Contractor's own expense, and shall be backfilled with selected borrowing material. Backfilling material in case of cable trenches should be as per the "Standard Specification for Roads and Bridges 2073 (Second Amendment 2078*1).

Excavation shall be maintained in a clean, dry, safe and sound condition until completion of the foundation construction and shall be done to prevent flooding by surface runoff. Suitable dewatering, if required, shall be adopted, and pumping equipment shall be provided and used to dewater excavation so that all installation work and backfilling is performed in dry state. Any previously prepared foundation bearing surface that is softened by water runoff or otherwise contaminated before placement of the foundation structure shall be excavated and replaced at the Contractor's own cost expenses.

In those excavation where the base is unstable, lies below groundwater level, or has been over excavated, the Contractor shall provide and place a layer of crushed stone, or selected backfill, or borrow to stabilize the base for placement of foundation as directed by the Employer/Engineer.



Any excavation left open during discontinuous construction which is accessible to the public or along public thoroughfare, shall be covered or barricaded, and marked by suitable visual means, to prevent a public hazard (as mentioned in JSSS).

A suitable metal sheet/mat shall be used to cover the backfilled trenches for easy traffic flow. The mat shall be such that it can take the weight of the vehicles.

Excavations shall be properly located and sized for the intended use. Pole and stay plate/ anchor excavations shall be correctly sized to retain undisturbed soil to the greatest extent consistent with the means of excavation. Pole holes shall be made by power-driven auger or by manual methods; power-driven shovel equipment shall not be used. Pole holes shall be excavated to the specified depth with no tolerance shallow and tolerance of ten (10) centimetres deep. The bottom of pole holes shall be undisturbed soil, gravel or rock. Stay plate holes shall be excavated by manual methods to specified depth with no disturbed soil in the direction of the anchor rod.

21.5 BACKFILL

All excavations shall be backfilled with excavated material, if allowed as per the standard or with 53 nominal size materials according to table 12.8 of "Standard Specification for Roads and Bridges 2073 (Second Amendment 2078)". Backfill shall be free of foreign materials and shall be well tamped with excess backfill graded over the excavated area to prevent depressions resulting from eventual natural compaction.

Backfill shall be placed in no greater than 20cm uplifts (each layer) before compaction. Each uplift shall be thoroughly compacted before the following uplift is placed, Pneumatic or equivalent tampers shall be used on cohesive materials: vibratory compactors shall be used on noncohesive materials. Compaction shall achieve a density at least 95% of the maximum dry density of the surrounding undisturbed earth. Large stones or rock fragments may be used in the backfill provided they do not interfere with proper compaction. Particles larger than 20 cm shall be placed not nearer than 0.5 m of the structure and at least 1.0m below ground surface.

Rock particles larger than 10 cm shall not be in contact with the concrete.

21.6 ROAD PAVEMENT

21.6.1 General Requirements

As a general rule, restoration of the paved road surface shall be performed using a heated asphalt mixture after the natural compaction for a period of at least two months.

Area of the road restoration shall be in accordance with the instructions from Department of Road (DOR) or the municipality.

The Contractor shall take the following steps to restore the road pavement.

- (a) Cleaning and Preparation: Remove any debris from the excavation area to ensure proper bonding of materials.
- (b) Restoring the Sub-base: Replace the sub-base (gravel or sand) to its original thickness, compacting it properly using tampers or vibratory rollers.
- (c) Restoring the Base Layer: Rebuild the base layer beneath the asphalt, ensuring it is well-compacted.



- (d) Laying the Asphalt Layer (Compatible to the existing type of top surface, it may be DBST or pre-mix Asphalt Concrete): Apply the asphalt layer to the original thickness, ensuring even spreading and proper compaction with rollers.
- (e) Finishing the Joints: Smooth the joints between the new asphalt and the existing road to achieve a seamless finish.
- (f) Surface Finishing and Inspection: Check the flatness of surface and the gradient required for proper drainage, making any necessary adjustments.

These steps help restore the road to its original condition and prevent future damage or settling.

In the case of the road with cement concrete surface, arrangements can be made to remove the entire concrete panel/slab of road surface and replace it with new concrete surface.

21.6.2 Road Restoration

Restoration shall be done in accordance with the latest "Standard Specification for Roads and Bridges or an instruction by Department of Road (DOR) or the local municipality.

Even if the Contractor adopts the temporary restoration without pavement, the process such as the backfill of soil and the compaction shall be conducted in compliance with the procedures described in this Chapter. The surface shall be covered by gravel.

The Contractor shall make a patrol periodically as required or at least every week. If the surface is settled, the Contractor shall restore it as soon as possible.

The permanent restoration with pavement shall be done after the natural compaction for at least 2 months.

The Contractor shall submit the road restoration plan for approval by the Engineer.

21.7 TIMBER SHORING

Close timbering shall be done by completely covering the sides of the pits generally with short, upright members called polling boards. These shall be of minimum 25 cm x 4-cm sections or as directed by the Employer or Employer's representative.

The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 meters spacing, strutted with bellies or as directed by the Employer or Employer's representative. The length of the bellies struts shall depend on the excavation and supported by vertical walling, which in turn shall be suitably strutted. The lowest boards supporting the sides of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit. The type of timbering shall be as approved by the Employer. It shall be the responsibility of Contractor to take all necessary steps to prevent the sides of excavations, pits, etc., from collapsing.

Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instruction from the Employer.



21.8 SELECT BORROW

Where the excavated material for the foundation is unsuitable for backfill or is required for construction of embankment, the Contractor shall select a borrow pit. Unsuitable excavated material for backfill/embankment purposes shall be disposed at the Contractor's own expense as directed by the Employer.

Material for selected borrow shall be well-graded bank run gravel, relatively free from clay, loam or vegetation matter and with no stones over 10 cm in maximum dimensions, or materials of equivalent strength and characteristics. Representative sample from proposed borrow sources shall be submitted to the Employer for approval of the borrow source. Approval of borrow source shall not mean automatic approval of all materials obtained from that source.

The select borrow shall be placed and compacted as specified for the backfill in 21.5 Backfill.

21.9 PERMISSION

Permission shall be taken by the Employer. The Contractor shall take the responsibility for assisting the procedure.

Prior to the commencement of any excavation or trenching works, the Contractor shall prepare and submit for approval a comprehensive Temporary and Permanent Road and Pavement Restoration Plan to the Employer/Engineer and the relevant Road/Urban Authority (e.g., DoR).

This plan shall include but not be limited to the following:

- (a) Detailed methodology for both temporary (emergency) and permanent restoration of all cut road surfaces, sidewalks, and other affected infrastructure
- (b) Type, grade, and specification of materials to be used for:
 - (i) Temporary surface reinstatement (e.g., cold mix asphalt, metal plates)
 - (ii) Permanent reinstatement (e.g., bituminous concrete, GSB/WMM, paving blocks)
- (c) Sequence of operations and construction procedures for restoration
- (d) Workmanship standards and reference to relevant national and international codes (e.g., Nepal Road Standards)
- (e) Traffic management and public safety measures during restoration activities
- (f) Schedule of restoration works in line with overall cable laying progress

The restoration plan shall ensure that:

- (g) Temporary restoration allows safe and unobstructed passage of vehicles and pedestrians during the construction period.
- (h) Permanent restoration restores the road or pavement to its original or better condition, as per the standards and requirements of the relevant authority.

The Contractor shall bear full responsibility for maintaining the restored surfaces until final completion and shall execute all restoration activities at no additional cost to the Employer.

The Contractor shall be fully responsible for the quality, stability, and durability of both temporary



and permanent restoration works carried out on roads, pavements, and other affected infrastructure.

In the event of any settlement, surface deformation, cracking, or any other defect or failure observed in the restored areas—whether during the construction phase or within the maintenance period—the Contractor shall:

- (i) Immediately investigate the cause of the issue
- (j) Promptly implement corrective measures to restore the affected area to the specified standard and original condition
- (k) Coordinate with the Engineer and concerned authorities for inspection and approval of the rectified work

No additional cost shall be claimed or paid by the Employer for such corrective works. All labor, materials, equipment, and associated expenses required for rectification shall be entirely borne by the Contractor.

21.10 FOUNDATION CONSTRUCTION

21.10.1 General requirements

All materials and labor required to remove and replace at his expense any materials incorporated in the work that do not conform to these Specifications.

- (a) The Contractor will be required to remove and replace at his expenses any materials incorporated in the work that do not conform to these Specifications.
- (b) The Contractors shall provide without extra cost all materials, which may be required for testing. The cost of the tests shall be borne by the Contractor.

21.10.2 Reference to standard specifications

Standard referred to in those specifications are as follows.

- (a) BS/IS/ASTM/Equivalent international standards refer to the latest edition of publications for materials.
- (b) BS/IS/ACI/AISC/Equivalent international standards refer to the latest edition of publications for design of structures and foundations.

21.10.3 Concrete

Nominal mix (ratio of cement, sand and gravel) of Concrete shall be 1:3:6 or 1:2:4. In case of Reinforced Cement Concrete, the nominal mix shall be 1:1.5:3. It shall be used as appropriate according to the application.

The work shall be as per the specification detailed in the subsequent clauses.

Concrete to be placed under water shall be deposited by tremie, and only after it has been determined by the Employer or Employer's representative that placing of concrete in an unwatered excavation cannot be practically accomplished by any other means. The tremie will not be allowed to drop below the level of water outside. Under no circumstances will concrete be allowed to drop through water within the tremie.



The tremie shall be watertight and sufficiently large to permit a free flow of concrete. The bottom of the tremie shall be as near to the surface against which the concrete is to be placed as practicable and the tremie shall not be raised until seal has been established by the concrete sufficiently to prevent the entry of water of the tremie. The discharge of the tremie shall be kept submerged in concrete at sufficient depth so as to maintain an adequate seal during underwater placement. Placing of concrete shall proceed without interruption until underwater placing in the foundation has been accomplished. As placing of concrete under water progresses, the Contractor shall remove water displaced by the concrete when the top of the concrete being placed by tremie reaches the elevation of the water table level; no further placement by tremie shall be performed.

21.10.4 Construction Materials

- (a) In locations where, in the opinion of the Owner/Engineer, the conditions required the use of high sulphate resistance cement, conforming to the requirements of ASTM C150 type V/Equivalent IS standard shall be used without any extra cost to the Owner.
- (b) The aggregates shall consist of clean, crushed materials or, subject to the approval of the Owner/Engineer, manufactured aggregate may be used.
- (c) Aggregates shall be separated into sand and coarse aggregate before being used. No pit or crusher run materials will be permitted without prior approval of the Owner/Engineer.
- (d) All construction materials shall be as per the relevant codal provisions and Field Quality Plan requirement.

21.10.5 Storage of materials

The General Requirement for Material Storage shall be referred to Sub Clause 1.6.7.

Cement and aggregate shall be stored at the site of the work in a clean condition and should not become contaminated with undesirable substances. Special care shall be taken in storing cement to keep it thoroughly dry at all times.

- (a) When reinforcing steel is procured to the store yard in advance of the Contractor's requirements, the Contractor shall provide suitable protection in order to prevent excessive rust developing on the reinforcing steel. It will be Contractor's responsibility to remove excessive rust.
- (b) Before starting of the foundation construction all screened aggregates and sand shall be collected and stockpiled near site. So that it is free from clay, dust and other foreign materials.

21.10.6 Concrete Mixing

- (a) Before any concrete mixing is begun, all equipment for mixing, transporting and placing the concrete shall be cleaned of all dirt and debris. All dirt and debris shall also be removed from the places to be occupied by the concrete.
- (b) All mechanical equipment shall be checked before starting a concrete placement to ascertain whether or not is in good operation condition, repaired or replaces to the satisfaction of the Owner/Engineer.
- (c) When a foundation location is ready for concrete placement, the Contractor shall inform Owner/Engineer before concrete placing time so that the Employer/Engineer may inspect to assure that the excavation is free of water, mud and debris; that the bottom surface of the



excavation is a well levelled and properly dressed; that the reinforcing steel is properly secured in place; and that the form-work is properly braced.

- (d) Rock surface shall be as flat as possible and projecting ridges shall be levelled off before the concrete is placed or space between the ridges shall be filled with concrete(1:4:8) to form a horizontal surface.
- (e) The Contractor shall ensure that all materials that is to be embedded in the concrete has been placed before pouring of concrete. The Contractor shall be responsible for the accurate location of all embedded materials. Any work in accurately or improperly set shall be relocated and rest reset at the Contractor's expense.
- (f) In case of nominal mix, the components of concrete are measured by volume. Volume measurements shall be made in standard measuring boxes.
- (g) The retempering of concrete, which has partially hardened, that is remixing with or without additional cement, aggregate or water, will not be permitted.
- (h) Concrete shall be conveyed from the mixer to the place of final deposit within 30 minutes by methods which will prevent the segregation or loss of the materials. After 30 minutes of mixing the mixed concrete shall be rejected and replaced by fresh concrete at Contractors own expense.
- (i) Equipment for chuting, pumping and pneumatically conveying concrete shall be of such size and design as to insured a practically continuous flow of concrete at the delivery end without separation of the materials. The chutes shall never be on a slope that is steeper than two vertical to three horizontal.
- (j) When the Concrete is to be placed on hard rock or other concrete, after the existing surface has been properly cleaned and otherwise prepared the existing surface is to be wetted until it is saturated. The cement slurry shall be evenly spread on the water- saturated surface and then normal concrete shall be deposited continuously and as rapidly as practicable.
- (k) The concreting shall be carried on at such a rate that the concrete is at all times plastic and flows readily into the spaces between the bars and so that each layer properly mixes with its predecessor. Successive layers shall be places within 15 minutes of the preceding layer.
- (l) When placing concrete with free drops over 1.5 meters, suitable chute arrangement may be made to avoid segregation of the concrete.
- (m) The concrete shall be consolidated during and after depositing by vibration, the concrete shall be thoroughly worked around reinforcement and embedded items and into corners of formworks.
- (n) The Contractor shall always have at least two vibrators in operating condition at the location of the concrete placement.
- (o) Vibrators shall not be used to transport concrete inside the formworks.

21.10.7 Concrete Testing

- (a) The Contractor shall complete concrete testing, the procedures shall be submitted and finalized before start of work. There shall be three cubes/cylinders to a set and the cubes/cylinders shall be made in accordance with relevant codes.



- (b) The Contractors shall deliver cubes/cylinders to a location of approved lab by the Owner/Engineer where they will be tested in accordance with BS/IS/ASTM C39/ Equivalent international standards.
- (c) In case of RCC nominal mixes, the minimum compressive strength shall be as detailed below:
- (d) RCC (1:1.5:3) shall be 265 kg/sq.cm.
- (e) RCC (1:2:4) shall be 210 kg/sq.cm.
- (f) The Contractor shall also pay for any additional concrete tests including core drilling and the repairs or replacements, which the Owner/Engineer deems necessary strength. If the RCC strength falls below minimum strength it should be dismantled and replaced at the same location.

21.10.8 Concrete Formwork

- (a) Formworks shall be used, wherever necessary to confine the concrete for structures and shape it to the required lines or to avoid contamination of the concrete by materials caving or sloughing from adjacent surfaces by excavated material.
- (b) Formworks shall be provided with tie rods and clamps to have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall be maintained rigidly in position. Formworks shall be sufficiently tight to prevent loss of mortar from the concrete. Moulding strips shall be placed in the corners of formworks so as to produce chamfered edges on permanently exposed concrete surfaces. All exposed surfaces shall be formed with plywood or steel sheathing. Unexposed surfaces may be formed with any materials of adequate strength and tightness to hold the plastic concrete in proper position and prevent the loss of mortar.
- (c) If plywood or steel formworks are not available, the Contractor may substitute wood planking provided exposed surfaces to remove ridges.
- (d) Before concrete is placed, the surfaces of all formworks shall be coated with a form oil that effectively prevents sticking and will not stain the concrete surfaces. For steel formworks, form oil shall consist of refined mineral oil compound.
- (e) Formworks shall be removed only after 24 hours of concreting or when the strength of the concrete is such that form removal will not result in cracking, spalling, or breaking of edges of surfaces, or other damage to the concrete. Any concrete damages by formworks shall be repaired immediately.

21.10.9 Concrete Finishing and curing

- (a) The exposed top surface of all concrete foundation piers shall be properly finished and shall be properly finished and shall be slightly sloped to prevent the accumulation of water.
- (b) Immediately after the removal of formworks, the holes left by form tie rod fastener shall be filled with mortar and all damaged or defective concrete shall be repaired or removed and replaced to the satisfaction of the Owner/Engineer. Improperly consolidated concrete shall be removed by chipping and the clipped openings or recesses shall be of such depth and shape are required to ensure that the patching materials placed in the openings or recesses will be thoroughly keyed and bonded to the concrete. "Dry pack" mortar shall be used for filling relatively deep chipped recesses with small surface dimensions. Concrete will be required for



the replacement of defective concrete where surface dimension of the chipped openings or recesses are relatively large. The depth of chipped recesses for concrete patches shall extend at least 25 mm beyond the nearest reinforcing steel.

- (c) To ensure proper curing, all concrete shall be kept moist for a period of a least ten (10) days. Burlap or and equivalent materials or a curing compound shall be applied over exposed concrete surfaces, the burlap shall be kept moist at all times.

21.10.10 Membrane curing compound

- (a) Wherever there is shortage of water for curing purpose, Membrane curing compound shall be applied (as per direction of employer) by uniform spraying, leaving no pinholes or gaps, at a rate not to exceed 4.91 square meters per litre. The curing compound shall be applied after finishing operations are completed and surface moisture has disappeared. If formworks are removed prior to 7 days placing the concrete, the uncovered surfaces shall be coated with the curing compound as specified herein.
- (b) Foundations shall not be backfilled before they have been inspected by Owner/Engineer to see that they are free from surface defects and voids, or that the defects and voids have been properly repaired.
- (c) The foundations shall not be subjected to any loads in addition to those existing at the time of placing of the foundation concrete until the curing period has elapsed.

21.10.11 HYSD/TMT reinforcing bar

All steel reinforcing bar shall conform to the requirement of IS 1786 or equivalent international standard.

- (a) Mill scale rust, oil and mud shall be removed from reinforcing steel by firm rubbing with burlap or equivalent treatment before the reinforcing steel is placed.
- (b) Reinforcing steel shall be accurately located and shall be secured in position by the use of binding wire and shall be supported in a manner that will keep the reinforcement away from the exposed concrete surfaces. Concrete blocks shall be used to support the reinforcing steel in the foundation mat: broken stones or wooden blocks shall not be used to supporting the reinforcing steel.

21.10.12 Grouting

- (a) Grouting for seating structural steel members and equipment on foundations shall be non-shrink (not-setting) Portland cement mortar grout or a suitable commercially available grout, at the Contractor's option. Grouting shall be done under pressure by means of an expanding agent or by means of static head. Propositioning and missing of grout shall conform to the following:
- (b) Mortar grout containing aluminium powder as an expansive agent mixture of 1 part cement and 2 parts sand, by weight, with a water cement ratio not exceeding 0.55 the quantity of aluminium powder used shall be approximately 0.005 percent of the weight of cement, the actual quantity to be determined from tests with materials to be used, and at the temperature and under the conditions of a placement. Aluminium powder shall be blended with cement in proportions of one part powder 10-50 parts cement, by weight and the blend shall be sprinkled over the dry batch. After all ingredients are added, the batch shall be missed 3 minutes. Grout,



which has not been placed within 45 minutes, shall be wasted.

- (c) In lieu of use of an expensive agent. Settlement shall be reduced by extending the missing period or by delaying final mixture to minimize the interval between time to placement and initial set and placement the under static header pressure. The motor grout shall be mixture of one part cement and 2.5 parts sand, with a water cement ratio of approximately 0.50 slump shall be the minimum necessary to enable placement.

21.11 FOUNDATION PROTECTION WORKS

Structure foundation located near the bank of the river, and other unstable places as directed by Employer shall be protected by stone masonry works and/or gabion wall. The Contractor shall undertake detailed study of such requirements during check survey in close consultation with the Employer or Employer's representative and submit design of such protection works for Employer's or Employer's representative's approval.

21.11.1 Stone Masonry Works

The stone shall be hand placed with un-coursed close joints to the lines and grades as designed. The rubble stone shall be placed with 1:3 cement sand mortar after having joints thoroughly moistened. The surface joints shall be finished with 1:3 cement sand mortar.

After completion of masonry wall, it shall be cured with water for more than 10 hrs.

Weep-holes with Perforated Poly Vinyl Chloride (PVC) pipes of 10 cm in diameter shall be placed in each 2 sq.m. of slope surface of the masonry wall or as required by site conditions. The upper surface of the masonry wall shall be finished smooth with concrete. The perforated pipe shall be extended at least 30 cm both ends from the stone masonry wall & in the backfilling end the perforated PVC shall be covered with gravel at least 30 cm in all-around insuring the filter zone.

21.11.2 Gabion Wall

The standard type gabion (Maccaferri) shall be a flexible hot dip galvanized gabion of the type and size specified below. It is made of wire mesh of the type and size and selvedge as specified in the following:

- (a) The mesh shall be hexagonal woven mesh with the joints formed by twisting each pair of wires through three and half turns.
- (b) The size of mesh shall conform to the standard specification issued by the factory and shall be not greater than 1/3 of the smallest stone filled in the gabion.
- (c) All wire used in the fabrication of the gabions and in the wiring operations during construction shall be "Mild steel wire", i.e. wire having average tensile strength of 44 kg/sq.mm.
- (d) The diameter of the wire used in the fabrication of the netting shall be at least 3.0 mm depending on the design requirement.
- (e) All wires used in the fabrication of the gabions and in the wiring operations during construction shall be hot dip galvanized.

All edges of the standard gabions including end panels and the diaphragms, if any, shall be mechanically selvedge in such a way as to prevent unraveling of the mesh and to develop the full strength of the mesh. The wire used for the selvedge shall have a diameter greater than that of the



wire used to form the mesh. Wire having a diameter of 3.0 mm and the selvedge wire shall have diameter equal to or greater than 3.9 mm.

The stone for the gabion shall be taken from the river deposit material or as approved by the Employer or Employer's representative. The rock shall be of compact, firmly-bound and uniformly grain texture and absolutely weather-resistance shall not have cracks, holes, laminations or detrimental materials. The stone blocks shall be of natural irregular cubical shape. The thin sliced blocks shall not be accepted. The size of stone shall be at least 10 cm.

The standard gabion shall have following dimension:

- (a) Length : 2.0 meter
- (b) Width : 1.0 meter
- (c) Height : 1.0 meter

Sufficient lacing and connecting wire shall be supplied with the gabions for all the wiring operations to be carried out in the construction of the gabion work. The quantity of such wire is estimated to be 8% of the gabion supplied. The 2.4 mm lacing wire shall be used for the gabion made of wire gauge 3.0 mm.

21.12 FQP: FIELD QUALITY PLAN

- (a) The material specification, workmanship and acceptance criteria and Contractor shall execute the work as per the approved Field Quality Plan (FQP).
- (b) The standards used may be BS/IS/ equivalent international standards.
- (c) Contractor shall submit the FQP for approval before commencement of works.
- (d) All testing required as per the approved FQP shall be arranged by the Contractor at his own cost including frequency tests also.

21.13 INTERFACING

The proper coordination & execution of all interfacing civil works activities like fixing of foundation bolts, 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 minimum.

21.14 SITE ACCEPTANCE TEST FOR EXCAVATION, BACKFILLING, INSTALLATION, MANHOLES

The tests shall include but shall not be limited to the following:

- (a) Depth Check: One sample every 200 mtrs, the Contractor shall prepare a sample pit at a location identified by the Employer. Depth of each item, warning tape, no. of warning bricks (if applicable), pipes, cable etc. shall be measured. Depth shall be as per technical specifications and shall correspond to recorded measurements.
- (b) The Contractor shall take records with photographs of depth check of each item.



- (c) Crossings: 10% of each type, visual inspection for checking conformance with drawings, thickness of Concrete, RCC Hume Pipe and GI pipe.
- (d) Manholes: As per technical specifications.

After inspection the Contractor shall backfill and carry out other restoration work at no additional cost to the Owner/Employer.



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CHAPTER 22:

INSPECTION AND TESTING



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CHAPTER 22: Inspection and Testing

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
22.1	SCOPE OF WORK	1
22.2	OBJECTIVES	1
22.3	QUALITY ASSURANCE, INSPECTION AND TESTING	1
22.4	TESTS AT MANUFACTURERS WORKs	2
22.4.1	General	2
22.4.2	Test Plans	3
22.4.3	Test Procedures	3
22.4.4	Test Records	4
22.4.5	Test Certificates	5
22.4.6	Type Tests.....	5
22.5	Responsibilities	5
22.6	Safety Procedures	6
22.7	Training of the Employer's Staff	6
22.8	Commissioning Staff	6
22.9	Test Equipment	6
22.10	Commissioning of Work.....	7
22.11	Commissioning Program	7
22.11.1	Test Procedures	7
22.11.2	Requirements for Field Tests	7
22.11.3	Records	8
22.11.4	"As-Built" Drawings	8
22.11.5	Test Method	8
22.11.6	Challenge Clause.....	9



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22.1 SCOPE OF WORK

The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer or their Representatives during manufacture, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications.

The Contractor shall provide all costs, appliances, apparatus, supervision, labour and services necessary to carry out all tests, unless specifically stated otherwise.

The Contractor shall furnish the detailed schedule of his commissioning plan at least one month prior to the scheduled date. The schedule shall include the commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.

The scope of the commissioning program includes the site testing and putting into successful operation of all the equipment supplied under the Contract, for 11kV and all secondary voltages systems.

22.2 OBJECTIVES

The objectives of commissioning work, prior to the successful energization of Plant at full voltage and connection to the system, are the following:

- (a) Confirm the integrity (correctness) of installation.
- (b) Confirm the integrity of insulation, connections and phasing.
- (c) Ensure proof of equipment characteristics.
- (d) Review workmanship.
- (e) Confirm the correct implementation of the design.
- (f) Check equipment ratings.
- (g) Check settings and operation of protective relays.
- (h) Check and measure resistivity of earthing grid and earthing system.
- (i) Confirm the proper functioning of SCADA system.

22.3 QUALITY ASSURANCE, INSPECTION AND TESTING

To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work, are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

- (a) His organization structure for the management and implementation of the proposed quality assurance program.



- (b) Documentation control system.
- (c) The procedure for purchases of materials, parts, components, and selection of sub-Contractors' services including vendor analysis, source inspection, incoming raw materials inspection, and verification of materials purchases.
- (d) System for shop manufacturing including process controls and fabrication and assembly controls.
- (e) Control of non-conforming items and system for corrective actions.
- (f) Control of calibration and testing of measuring and testing equipment.
- (g) Inspection and test procedure for manufacture.
- (h) System for indication and appraisal of inspection status.
- (i) System for quality audits.
- (j) System for authorizing release of manufactured products to the Employer.
- (k) System for maintenance of records.
- (l) System for handling storage and delivery.
- (m) A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.

The quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

(1) Quality Assurance Documents

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of material/equipment.

The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the sub Contractor's Quality Management and Control Activities.

(2) Inspection, Testing and Inspection Certificates

The provisions of the clauses on Test and Inspection of the General Conditions of Contract and Special Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification.

22.4 TESTS AT MANUFACTURERS WORKS

22.4.1 General

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant British, IEC Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall



be subject to the Employer's approval.

At least fifteen (15) days' prior notice, in writing or by tele-fax, shall be given to the Employer of the readiness of the plant for test or inspection and every facility shall be provided by the Contractor and sub-Contractors to enable the Employer or their Representative to carry out the inspections and witness the tests. This includes progress, test rig and packing inspections also.

No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests. All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer. The costs of carrying out such calibration shall be borne by the Contractor in all cases.

The costs of making/performing any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The cost associated with travel, lodging and fooding shall be borne by the Contractor, and shall be included in the Price Schedule. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/testing requirements.

RMU	2 persons, 1 visit, for seven (7) days
XLPE Power Cable	2 persons, 1 visit, for seven (7) days

In addition, the Consultant shall also witness the routine tests of RMU, XLPE Power Cable.

The Employer also reserves the right to conduct all tests mentioned in this Specification at his own expenses on the samples drawn from the site at Contractor's premises. In case of evidence of non-compliance, it shall be binding on the part of the Contractor to prove the compliance of items to the technical specifications by repeat tests.

22.4.2 Test Plans

After completion of the tests, triplicate sets of all principal test records, test certificates and performance curve

22.4.3 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 (4) 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 below.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on



and beyond the testing date. The time elapsed 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.

- (a) Description
- (b) Test Title and Revision Level, if applicable
- (c) List of Standard(s) complied with
- (d) Function(s) / parameter(s) to be tested
- (e) Purpose of each test segment
- (f) List of required test equipment
- (g) Description of any special test conditions or special actions required.
- (h) 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.
- (i) Test setup including test configuration block diagrams and/or illustrations.
- (j) Test procedures to be followed.
- (k) Required inputs and expected outputs for each test segment
- (l) Acceptance criteria for each test segment.
- (m) List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
- (n) Format of test reports.

22.4.4 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 below.

- 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

22.4.5 Test Certificates

After completion of the tests, triplicate sets of all principal test records, test certificates and performance curves shall be supplied to the Employer.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.

When all equipment has been tested, test certificates of all factory and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Consultant and five copies to the Employer.

22.4.6 Type Tests

Type tests are required to prove the general design of the equipment and the Contractor may submit certificates of such design tests, which have been carried out on identical equipment. Notwithstanding any provision in BS, IEC or ANSI Standards, the Employer shall have the right to accept such certificates in lieu of the specified type tests or to reject them.

The type tests prescribed shall be carried out at the Contractor's cost in all cases, where either such certificates are not available or are rejected by the Employer.

If satisfactory evidence of such type testing is not available, the same are to be carried out in the presence of NEA Engineer. The costs if any for such tests are deemed to be included in the contract price.

The proposed manufacturers of Power cables, Conductor, Fibre Optic cables, RTU, RMU, LT pillar and equipment for SCADA are required to be certified on their conformity to ISO 9001 by an accredited certification agency.

22.5 RESPONSIBILITIES

To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.



The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.

The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

22.6 SAFETY PROCEDURES

The Contractor shall share the responsibility for safety procedures with the Employer. The Contractor shall establish and implement a work permit and tagging system and associated safety procedures (subject to the review of Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.

The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energizeable from the existing system.

22.7 TRAINING OF THE EMPLOYER'S STAFF

The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis, or in the commissioning work and:

- (a) Allow the Employer's staffs to become familiar with the operating and maintenance aspects of the new equipment supplied by him especially RMU, Feeder Pillar, MPLS Equipment,
- (b) Maintain a continuing assessment with the Employer of the precautions required in or possible consequences of, initial energization of equipment,
- (c) Allow for the above two necessary objectives in the preparation of schedules.

22.8 COMMISSIONING STAFF

The Contractor shall provide commissioning personnel including skilled and unskilled labour as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.

Ensure that only staffs assigned to commissioning fulfils that duty for the duration of the assignment.

Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

22.9 TEST EQUIPMENT

The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.



Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

22.10 COMMISSIONING OF WORK

After completion of entire work of any village or load centre, the project after necessary tests shall arrange to electrically charge the same. In case of successful operation in satisfaction to the project the Contractor shall be issued a provisional certificate starting from the date of such commissioning.

The Project shall be authorized to change such date of commissioning in case of failure of the line due to any defect in the quality of construction.

Final acceptance of work shall be issued only after completion and satisfactory commissioning of whole work of the contract.

22.11 COMMISSIONING PROGRAM

Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.

Carry out all testing during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.

Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

22.11.1 Test Procedures

The following basic tests, in addition to others, shall be carried out:

- (a) Measurement of insulation resistance.
- (b) AC withstand voltage test

22.11.2 Requirements for Field Tests

The field tests shall be carried out in presence of Employer under the following conditions:

AC withstand test voltages for conductors and outdoor equipment shall be normal operation voltage of the distribution line and, withstand voltage test shall be carried out for ten (10) minutes by the normal voltage mentioned above. The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.

Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.



Measurement of insulation resistance of the equipment shall be performed by at least 2500V (HT)/1000V (LT) megger.

After completion of the measurement of insulation resistance mentioned above, ac withstand voltage test shall be performed by the normal operation voltage of the existing power system in accordance with the following procedure:

- 11 kV Main Circuit: The 11 kV RMUs, circuit breakers and disconnecting switches, except for circuit breakers receiving power for the test from the existing power system through a distribution line, shall be closed, succeeding, normal operation voltage shall be charged on the equipment and bus conductors for ten (10) minutes for ac withstand voltage test. The indication value of meters mounted on the board during the ac withstand voltage test shall be recorded on the test record sheets prepared by the Contractor.

Submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. Strictly adhere to these procedures for the commissioning tests.

22.11.3 Records

Maintain an up-to-date record of all commissioning activities on site.

Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future. Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results.

22.11.4 "As-Built" Drawings

Keep an ongoing record of all changes on a master set of drawings including updated GIS. Produce and supply a minimum of five (5) complete sets of marked-up "As Constructed/As-Built" drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification. As built drawings shall also be submitted in electronic copy.

22.11.5 Test Method

Carry out all necessary tests for commissioning the OH lines, UG Cables, RMU, Feeder Pillars, Telecommunication Equipment etc. The following clauses detail the tests which are considered to represent the minimum required in addition to those specified under the appropriate IEC Publications, other approved standards and the manufacturer's instructions for each item of equipment.

Strictly adhere to the methods of testing approved by the Employer.

A) Site and Commissioning Tests for Main and Auxiliary Equipment General Checks:

Make a general check of all main and auxiliary equipment. Include a check of the completeness, correctness and condition of ground connections, labeling, arcing ring, paint surfaces, cables, wiring, pipe-work, valves, blanking plates and all other auxiliary and ancillary items.

Check for oil and gas leaks and that insulators are clean and free from external damage. Check



that loose items, which are to be handed over to the Employer, e.g., blanking plates, tools, spares, etc. are in order and are correctly stored or handed over.

22.11.6 Challenge Clause

The equipment/material offered/received after the inspection by the authorized inspecting officer may again be subjected to test for any parameter from any NEA laboratory or NEA approved laboratory & the results if found deviating/un-acceptable or not complying to Technical specification, the bidder shall arrange to supply the replacement within thirty (30) days of such detection at his cost including to & for transportation and required custom. In addition, penalty @10% of cost of the inspected lot of material shall be imposed. Further, any additional inspections on the replaced equipment/material shall be borne by the Contract.

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CHAPTER 23:
DESIGN REQUIREMENTS FOR RIVER CROSSING



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CHAPTER 23: Design Requirements for River Crossing

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
23.1	General	1
23.1.1	Applicable Standards	1
23.2	Detailed Works	1
23.3	Equipments	1
23.3.1	General	1
23.3.2	Supporting Structure	1
23.3.3	Conductor	2
23.3.4	Insulator and Insulator Strings	2
23.3.5	Hardware Fittings.....	2
23.3.6	Stay Wires	2
23.3.7	Foundation work and Piling work	2
23.4	Technical Requirement.....	2
23.4.1	Line Clearance.....	2
23.5	Test.....	3



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23.1 GENERAL

The chapter covers design of supporting structure, conductor, stay wires and the accessories, foundation work, piling work for river crossing of overhead conductors.

The Contractor shall take the responsibility of design of the particulars above, and also provide the Employer with complete documentation for the prior approval of the Employer.

23.1.1 Applicable Standards

Applicable Standards shall be referred to the Chapter for each equipment in this Technical Specification.

23.2 DETAILED WORKS

Bidders are advised to conduct site surveys at their own expense before proposal submission. After contract award, the Contractor must perform necessary surveys at all sites, coordinating with the Employer.

In the detailed design stage, the Contractor must submit a design report for river crossing point of conductor, including equipment layout, the civil works, and result of technical calculations. The report shall include at least the following items:

- (a) Proposed layout of Equipment at river crossing point
- (b) Proposed civil works (foundation work and piping work)
- (c) The supporting result of technical calculation (Sag and Isolation distance of Conductor, conductor tension, result of geological survey, etc)

23.3 EQUIPMENTS

23.3.1 General

The Fittings shall be free from defects, corrosion protected and shall meet the requirements of Galvanizing Test etc as per IS.

All forging and casting shall be of good finish and free from flaws and other defects. The edges of the fittings such as the tongue, clevis and holes shall be rounded.

Spring Washer shall be electro galvanized. The coating thickness as per IS: 1573-1986.

The other metal equipment shall be Hot dip galvanized, and the minimum value of zinc coating shall be 610 g/m².

23.3.2 Supporting Structure

The Contractor shall choose steel tubular poles or steel lattice tower as the supporting structure. If steel tubular poles are adopted, considering the sway of conductors and isolation distance between conductors, the number of poles shall be finalized.

The height of the supporting structure shall be designed considering sag of conductor and water level of the river including water level during the flood season.



23.3.3 Conductor

XLPE covered AAA Conductor or covered ACSR Conductor shall be used for the conductor. The size of Conductor shall be 100 mm sq (DOG conductor).

23.3.4 Insulator and Insulator Strings

Disc Insulators shall be generally used, the number of insulators per conductor and the connection (parallel connection or serial connection) shall be determined by the Contractor.

23.3.5 Hardware Fittings

The Dead End Clamp shall be suitable for supporting conductors. The Clamp comprises of outer sleeve and inner sleeve. Outer Sleeve & Jumper Cone shall be made of EC grade Aluminium. The inner Sleeve is Steel Sleeve & shall be made by Forged Steel. The steel sleeve of Dead End Clamp shall be single piece obtained by process of drop forging and shall not be made by joining, welding, shrink fitting or any other process for more than one piece of material. The steel sleeve shall be hot dip galvanized.

Dead End Clamp and the other accessories shall be capable of withstanding an ultimate strength of 70 kN.

23.3.6 Stay Wires

The Contractor shall take the responsibility of the design. The size of stay wires and the anchor spread shall be determined by considering the conductor's tension strength.

This river crossing equipment will be vital facilities for the power distribution, so not only stay wires but side guy wires are also installed considering the sway of conductors.

23.3.7 Foundation work and Piling work

Foundation work shall be done referring to the drawings in the Appendix. The Contractor shall conduct a geological survey prior to the design work, and determine the necessity of the piling works.

23.4 TECHNICAL REQUIREMENT

23.4.1 Line Clearance

Horizontal clearance between two conductors on the same supporting structure shall not be less than 323 mm.

Vertical clearance between conductor and water surface shall not be less than value in the Table below. If span exceed 105 m in length, the clearance listed below shall be increased 0.03 meters for each 10 meter of excess of span length over 105 m.

Water Area	Vertical clearance (m)
Less than 10 Hectares	6.1
10 to 80 Hectares	8.5
80 to 800 Hectares	10.4
Above 800 Hectares	12



23.5 TEST

Test requirements for each equipment shall be referred to the Chapter for each equipment.



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CHAPTER 24:
SAFETY SPECIFICATION



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CHAPTER 24: Safety Specification

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
24.1	GENERAL REQUIREMENTS FOR SAFETY SPECIFICATION.....	1
24.2	JICA STANDARD SAFETY SPECIFICATION.....	1
24.3	PARTICULAR SAFETY SPECIFICATION	1
24.4	SITE OFFICE MANAGEMENT.....	1
24.5	CONTRACTOR'S HEALTH AND SAFETY OBLIGATIONS.....	1
24.6	CONTRACTOR'S SAFETY PLAN	2
24.7	HEALTH AND SAFETY OFFICER	2

Annex.24-1 Particular Safety Specification (PSS)



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24.1 GENERAL REQUIREMENTS FOR SAFETY SPECIFICATION

The Contractor shall be responsible to fully comply with JICA Standard Safety Specification (JSSS), Ver.1.0 February 2021 issue (or latest version).

The Safety Specification shall consist of two (2) parts, namely:

- (a) Part 1; JICA Standard Safety Specification (JSSS)
- (b) Part 2: Particular Safety Specification

The Safety Specification shall be incorporated in part of the Employer's Requirements, and have priority over the other parts of the technical specifications in respect of health and safety matters.

24.2 JICA STANDARD SAFETY SPECIFICATION

The Contractor (Bidder) shall refer to JICA Standard Safety Specification, shown in the JICA homepage as follows:

https://www.jica.go.jp/Resource/english/our_work/types_of_assistance/c8h0vm00008zx0m8-att/jsss_01.pdf

24.3 PARTICULAR SAFETY SPECIFICATION

The Particular Safety Specification comprises a schedule containing the particular additions and modifications to JSSS, necessary to create a precise and relevant specification for the health and safety requirements for the Project.

Within the Safety Specification, the Particular Safety Specification have priority over JSSS.

The Particular Safety Specification for this project is in Annex.24-1 enclosed hereafter this Chapter.

24.4 SITE OFFICE MANAGEMENT

The Contractor shall establish and maintain throughout the period of the performance of the contract a site office to serve as a base for all the operations necessary to perform the works and shall maintain adequate store facilities for storing materials and equipment issued by the Engineer. In case the above-mentioned facilities and establishments are not found satisfactory during the site verification, the Engineer shall have right to instruct the Contractor for rectification of the same.

24.5 CONTRACTOR'S HEALTH AND SAFETY OBLIGATIONS

The Contractor shall be fully responsible for the health and safety on the Site, for the Works, his personnel, sub-contractors' personnel, the public domain and all persons directly or indirectly associated with the Works, on or in the vicinity of the Site in accordance with Clause 6 of General Conditions.

The Contractor shall submit the Safety Plan to the Engineer for review, which shall be incorporated in the Programme. The Contractor's health and safety activities shall be monitored and recorded on a daily basis.

The provisions in the Contract Documents regarding the health and safety shall apply to the Contractor and his sub-contractors of any level for any part of the Works.



The Employer reserves the right to order the immediate removal and replacement of any item of Contractors Equipment or Temporary Works, which in his opinion, is unsatisfactory for its purpose or is in an unsafe condition.

The safety requirements specified here shall be strictly followed as a minimum throughout the Project construction period. There is no restriction for the Contractor to follow his own additional safety measures.

24.6 CONTRACTOR'S SAFETY PLAN

The Safety Plan shall be submitted by Contractor (and Bidder) as per the requirements mentioned in the Safety Specification.

24.7 HEALTH AND SAFETY OFFICER

The Contractor shall appoint a Health and Safety Officer (HSO) as per the Safety Specification.

The appointment and designation of HSO shall be subject to the Engineer's approval. Unless specifically agreed in writing by the Engineer, the Contractor shall not undertake any work on the Site until the Health and Safety Officer has commenced duties on Site.

The Contractor shall provide an HSO with enough supporting staffs in accordance with the staffing levels set out in the Safety Specification.

Annex.24-1 Particular Safety Specification (PSS)

1. GENERAL

The Particular Safety Specification shall supplement corresponding clause of JSSS. Whenever there is a conflict, the provisions herein shall prevail over those in JSSS.

2. PARTICULAR SAFETY REQUIREMENT

CHAPTER 1: GENERAL REQUIREMENTS

1.7.7 (1) BASELINE SAFETY PLAN

1.7.7 (1) shall be replaced with the following.

The Baseline Safety Plan shall be submitted within 60 days from the Commencement Date or at least 45 days prior to the start of construction activities, whichever comes earlier.

1.7.9 PROCEDURES FOR SUBMISSION AND REVIEW

Clause 1.7.9 (2) (b) shall be replaced with the following sentence.

The Particular Safety Plans by the date forty five (45) days prior to the commencement of each particular part of the Works where sufficient detail has not been included in the Baseline Safety Plan and/or within twenty eight (28) days after the date of the Engineer's request.

Only in exceptional circumstances, submission up to fourteen (14) days prior to the commencement of work may be permitted.

1.12 HEALTH AND SAFETY OFFICER AT THE SITE (HSO)

Specific requirement shall be referred to Vol.1 EQC 1.1.1 Personnel.

In accordance with Clause 1.13.1 of JSSS, the HSO shall devote his full time and attention to maintaining health and safety upon the Works and protecting against accidents.

The HSO (Health and Safety Officer) shall be assigned exclusively and shall not concurrently perform any other duties or hold additional positions.

1.12.2 SUPPORTING PERSONNEL

The number of supporting personnel of HSO shall be one (1).

1.21 SKILL TRAINING

In accordance with Clause 1.21.4 of JSSS, the Contractor is not allowed to bring into the Country for use upon the Works any unqualified, unskilled or inexperienced foreign Contractor's Personnel.



1.22 DANGEROUS WORK

The following works are expected as dangerous works in the Works:

- Welding work, Hot cutting work, and Demolition work
- Construction of Trench and manhole on the heavy traffic road during day and night time
- Shuttering work for cable manhole construction
- Work in closed place (tank, cable manhole, etc)
- Foundation work of special branch tower (live line proximately work)
- Equipment Installation work of special branch tower (live line proximately work)
- High place work at Transmission Tower and Utility Poles
- Transmission line work and Distribution line work (Live line proximity work and de-energized work)
- Work near the energized electrical facilities such as high voltage cable, exposed power line, switchgear and transformer

The above list is just examples of dangerous works, the Contractor shall take responsibility for the dangerous works, shall suggest additional dangerous work in the safety plan.

It shall be the Contractor's responsibility to provide appropriate insurance, safety and health management, security measures, and welfare facilities for such hazardous work at the own cost.

1.22.11 HAZARDOUS SUBSTANCES

There is not expected to be likelihood of the existence of Hazardous Substances such as UXO at the construction site of Birauta substation and along the underground cable route.

1.23 PERMIT TO WORK SYSTEM – DANGEROUS WORK

(1) General Requirements

'Permit To Work' includes the following information as the minimum requirements.

The 'Permit to Work' shall be arranged through the Project and the same shall also be got cancelled through the project only.

Dangerous works shall not commence until the PTW is fully completed, reviewed, signed by all responsible parties (e.g., Work Supervisor, Health and Safety Officer, and Site Manager), and visibly displayed at the worksite.

All PTW records shall be maintained in the site safety file and organized in a manner that allows for audit and verification.

No.	Category	Detail
1.	Basic Information	Work title, location, date, scheduled start and end times, responsible person(s)
2.	Worker Information	Names of supervisors and workers, qualifications or certifications (license numbers, if applicable), number of workers involved
3.	Work Description	Brief explanation of the task (e.g., welding work inside substation, etc.)
4.	Equipment and	List of tools, flammable materials, hazardous substances, or



	Material Used	electrical equipment to be used
5.	Key Work Procedures	Outline of essential safety procedures (detailed method statements may be attached separately)
6.	Identified Risk and Control Measures	Description of potential hazards (e.g., fire, electric shock, toxic gas, falls) and specific control measures such as LOTO, ventilation, or assignment of standby personnel
7.	Work Conditions and Limitations	Conditions for work approval or suspension (e.g., "work shall be suspended if wind speed exceeds XX m/s" or "delay work if heat stress index exceeds safe threshold")
8.	Pre-work Safety Inspection Checklist	Confirmation of gas leakage tests, grounding measures, voltage absence, ventilation, etc.
9.	Approval Signatures	Signature fields for the Work Supervisor, Health and Safety Officer, and Site Manager
10.	Emergency Contact Information	Emergency contact numbers (fire department, ambulance, safety personnel), location of emergency stops and evacuation routes

(2) Substation Work (Electrical)

After partial or complete energization of substation equipment, the Work Supervisor to undertake involving work shall take the Permit to Work from the responsible person in charge of substation operation.

A minimum seven (7) day advance notice in writing for the de-energization of necessary part of the equipment shall be given to the Project.

Before the starting of the involving work, the Work Supervisor shall confirm de-energization of the equipment by earthing and voltage detector. Also, other living facilities shall be clearly indicated and isolated from involving facilities.

After involving work is completed, the Work Supervisor shall check the evacuation of personnel and tools from job site and the earthing is disconnected.

(3) Substation Work (Civil and Building)

Before starting demolition work, the Contractor shall ensure that all utilities such as electricity and water supply are properly disconnected.

(4) Transmission Line Work

For foundation work and equipment installation work (such as lightning arrestors and cable sealing ends) can be expected to involve live line proximity work.

Heavy machinery such as cranes must maintain a minimum distance of 3.05 meters (10 feet) from energized 132 kV transmission, the Contractor shall monitor the safety during the work.

For the erection and stringing work of the lines, the Contractor shall request the Employer for power shutdown of existing transmission line, where necessary, at least 6 months in advance. The request letter or form shall include the place of work and duration of shutdown needed. The period of shutdown shall be as minimum as possible. The Employer has right to decrease the justified period of shutdown, if requested period of shutdown by Contractor is excessive and to shift the date of shutdown.

The Contractor shall complete the work, during the shutdown period within the stipulated time period.



If the Contractor fails to complete the work within the stipulated time limit, the Employer will claim the amount of money arising from the loss of energy not transmitted or distributed.

The Contractor shall obtain a PTW prior to undertaking a work near the energized transmission line, work on the de-energized line (including installation of temporary protective earth before work), and high place work (including tower climbing).

(5) Distribution Line Work

The Contractor shall inform the Project Manager whenever he wants to avail the 'Permit to Work' from the local distribution centre for erecting the new 11 kV line or augmenting the existing 11 kV line.

A minimum seven (7) day advance notice in writing for availing the shutdown on any live 11 kV feeder/LT lines shall be given to the Project.

Even after taking the "Permit to Work", the Contractor must verify the absence of voltage with voltage detector before commencing the work.

The 11 kV/ LT line on which permit is taken shall be made clear from all the temporary protection earth, men and material before cancellation of the 'Permit to Work'.

1.24 ACCIDENT RESPONSE PLAN

As there are several hospitals near the construction site in Pokhara that provide 24-hour medical services, the establishment of a dedicated medical facility within the site shall not be required. But AED and facilities capable of providing first aid treatment for injured or ill persons shall be equipped at the construction site.

Examples of hospitals with 24-hour availability in Pokhara are listed below.

1. Manipal Teaching Hospital

Operator	A private teaching hospital affiliated with Kathmandu University.
Departments	General Medicine, Surgery, Internal Medicine, Obstetrics and Gynecology, ICU, Orthopedics, among others.
Operating Hours	Outpatient Services: 9:00 AM – 3:00 PM (Sunday to Friday) Emergency Services: 24 hours

2. Gandaki Medical College Teaching Hospital

Operator	A private teaching hospital affiliated with Tribhuvan University
Departments	A wide range including Internal Medicine, Surgery, Neurology, Ophthalmology, ENT, Dentistry, etc.
Operating Hours	Outpatient Services: 8:30 AM – 2:30 PM (Sunday to Friday) Emergency Services: 24 hours

1.30 HEALTH AND SAFETY COORDINATION WITH OTHER CONTRACTORS

There are no other Contractors employed by Employer near the construction site.



1.36 HEALTH MATTERS

The Contractor shall collect wastes from and clean in accommodation facility, offices, workshops and work sites on a daily basis and transport it to an area approved by the Employer and Engineer. The Site shall be kept clean and free of refuse at all times. No waste shall be dumped in areas other than the locations designated by the Contractor and approved by the Employer and Engineer for waste disposal. No waste of any kind shall be deposited in any watercourses.

1.36.4(2) PROVISION OF ANTI-MOSQUITO MEASURE

Safety Measure for mosquito shall be required in the project area.

1.38 UNEXPLODED ORDNANCE (UXO)

There is not expected to be likelihood of the existence of Hazardous Substances at the Site.

ANNEX 1.2: CONTENT OF BID STAGE SAFETY PLAN

A1.2.2 (9) SAFETY PLAN FOR THE WORKS

The anticipated work activities and associated hazards in this project are listed in the table below. The Contractor must ensure that the safety measures for each work activities are fully implemented.

Work activities in the table are not comprehensive, the Contractor shall make safety plan for anticipated work in the Project.

Work Activity	Main Hazards	Notes
1. Substation Work (Electrical)		
Work near live equipment	Electric shock, arc flash	Live work generally prohibited unless under strict control
High-voltage withstand/insulation testing	Electric shock, equipment rupture	Requires controlled environment and trained personnel
Grounding installation	Electric shock due to potential difference	Especially hazardous during fault conditions
Cable termination (heat application)	Fire, burns, inhalation hazard	Ensure proper ventilation and flame control
2. Substation Work (Civil & Building)		
Demolition work	Collapse, dust	Safety barricade and water spraying
Excavation (foundation, pit, cable trench)	Collapse, buried utility strike	Use shoring and pre-surveys
Piling Work	Machine overturning, falling objects	License or training of operator required
Work near floor openings	Falls, dropping tools	Install covers and clear signage
Formwork, rebar work and scaffolding	Punctures, falls	Rebar caps and scaffolding checks required
Concrete casting	Formwork failure	Supervised pouring and curing control, check formwork strength, emergency plan in place
Work at heights	Falls, dropped objects	Use of full-body harness mandatory



	Falsework, temporary supports and scaffolding	Collapse of formwork, earth retaining, shoring and scaffolding	Design and inspection documentation required
	Painting/plastering (organic solvents)	Solvent inhalation, falls	Respiratory protection and ventilation required
3. Substation Work (Heavy Equipment & Machinery)			
	Equipment delivery using cranes	Crushing, suspended load drop, machine overturing, overloading, strong wind	Signalmen and exclusion zones required, license required
	Cable laying from drums	Reel tip-over, entanglement	Secure drum stands and use proper rollers
	Transformer/GIS installation	Crushing, overturning	Use level base and rigging plan
4. Overhead Transmission Line Work (Foundation & Ground)			
	Borehole drilling, soil testing	Machine entanglement, cave-in	Monitor ground conditions and machinery limits
	Foundation excavation	Collapse, buried objects	Shoring and excavation permits needed
	Earth retaining work	Structural failure	Pre-approved temporary work plans
	Anchor embedding and concrete work	Tripping, entrapment	Level monitoring and proper mix procedures
5. Overhead Transmission Line Work (Tower Assembly and Erection)			
	Component assembly (on ground)	Crushing, tool mishandling	Work zone isolation necessary
	Tower erection (crane or jacks)	Suspended load risk, collapse	Rigging plan and load chart compliance
	High-place work (tower top)	Fall, object drop	Full-body harness with fall arrest
	Brace and wire installation	Electric contact, whipping wires	Clearance from energized lines mandatory
	Adverse weather work (wind, lightning)	Gust-induced falls, lightning strike	Wind speed ≥ 15 m/s requires work suspension
6. Underground Transmission Line Work and Distribution Line Work			
	Trench excavation (manual or mechanical)	Cave-in, buried utility damage	Use shoring, perform utility checks
	Pavement cutting (asphalt/concrete)	Blade injury, flying debris, dust	Use water cooling, PPE, isolation barriers
	Earth retaining/shoring	Collapse, material fall	Install supports per plan, daily inspection
	Underground crossing (jacking/shield)	Oxygen deficiency, machinery damage	Forced ventilation and gas detectors mandatory
	Conduit installation	Snap-back, entrapment	Use proper tools and team coordination
	Manhole/joint pit construction	Fall into openings, toxic gas	Guard openings, monitor air quality
	Concrete work (underground)	Formwork collapse, slips	Adequate access and curing supervision
	Work inside pits and manholes	Confined space risks	Atmospheric testing, ventilation
	Cable delivery and pulling	Reel instability, tension break	Use of pulling winch with load monitoring
	Jointing/termination work	Electric shock, fire	Flame control and insulation check required
	Withstand & continuity testing	Shock, arc flash	Post warning signs and restrict access
	Backfilling & compaction	Equipment collision, burial hazard	Spotters and phased filling techniques
	Pavement restoration	Burns, vibration, traffic hazards	Control heat exposure and secure work zone



	Work on public road	Traffic accidents	Safety guards and safety barricade
7. Overhead Distribution Line Work			
	Pole removal or erection	Tip-over, entrapment	Pre-burial depth and utility check mandatory
	Excavation for poles	Striking buried objects	Visual and marked inspection zones required
	Stay wire (guy wire) installation	Snap-back injuries	Ensure tension control and anchor strength
	Conductor stringing & re-tensioning	Wire breakage, entanglement	Controlled tension monitoring and exclusion zone
	Heavy equipment lifting (e.g., pole-mounted transformers)	Suspended load, falling objects	Signal control and PPE enforcement
	Conductor removal and winding	Flying cable ends, rollback	Controlled winding and team communication
	High-voltage proximity work	Shock, arc fault	Insulated gloves/tools and exclusion distance
	Bucket truck work	Falls, tipping	Full harness and vehicle inspection required
	Roadside work	Traffic accidents	Traffic control plan and flaggers essential

A1.2.2 (22) ENVIRONMENTAL, TEMPORARY WORKS AND STRUCTURAL MONITORING PLANS

The Contractor shall ensure that the contents of the clause are consistent with those of Environmental Management Plan (EMP) and Construction Environment Management Plan (CEMP). The specific requirement for monitoring and record shall be referred to Vol.2A-2_Chapter 16, Vol.3B-2_Chapter 17, Vol.4C-2_Chapter 25.

CHAPTER 2: GENERAL SAFETY MEASURES

2.1.1 HAZARDOUS SUBSTANCES

There is not expected to be likelihood of the existence of Hazardous Substances at the Site.

2.1.2.(4) ASBESTOS

Existing buildings to be demolished don't contain any asbestos in the components.

2.1.3.(2) POOR VENTILATION

Clause 2.1.2 shall be supplemented with the following sentences:

Furthermore, if entering a location where ventilation is considered insufficient, the oxygen concentration should be measured using an oxygen meter each time to ensure safety. In addition, if the generation of hydrogen sulfide or other toxic gases is expected, adequate ventilation must be provided.

2.1.7 (6)-(13) MONITORING AND RECORDING

Requirement for monitoring and record shall be referred to Vol.2A-2_Chapter 16, Vol.3B-2_Chapter 17, Vol.4C-2_Chapter 25.

This requirement represents the minimum standard, and compliance with it does not exempt the Contractor from its contractual responsibility to carry out the Works without causing damage to other property.

2.2.2 WORKING AREA PERIMETER

The Contractor shall follow the following requirements for the Construction fence, and as a general, security personnel shall be arranged by Contractor at the own expense.

(1) Temporary Fence for Welding Works and Hot Cutting Works

Temporary Fence for welding works and hot cutting works shall be satisfied with the following requirement.

Parameter	Requirement
Fence Type	Temporary steel or plastic barricade with mesh or panel type design
Fence Height	Minimum 1.8 meters (for outdoor) Minimum 1.2 meters (for indoor)
Minimum Clearance Radius	More than 3 meters from welding point
Foundation	Weighted base or anchored posts (stable against wind)
Visibility Control	Opaque flame-retardant welding screen or curtain shall be attached to block arc light
Fire Protection	Flame-resistant tarpaulin or spark-resistant blanket shall be applied inside the fence area
Opening Access Gate	For Welder only, kept closed during operation

(2) Temporary Fence for Constructing Scaffolding Zone

Parameter	Requirement
Fence Type	Temporary steel or plastic barricade with mesh or panel type design
Fence Height	Minimum 1.8 meters
Marking	Display warning signs in English and local language – “Scaffolding Work in Progress” – “No Unauthorized Entry” – “Falling Objects Risk”

Reinforcement	Use additional braces or sandbags in windy conditions
Lighting	Provide LED lights along fence perimeter if working at night

(3) Barricade for Energized Area

When construction work is performed in an energized distribution substation, authorization shall be obtained from the Employer's designated, authorized person before work is started by the Contractor. When work is to be done in an energized distribution substation, the Contractor to fully understand the following;

- What facilities are energized, and
- What protective equipment and precautions are necessary for the safety of personnel.
- Barricades or barriers shall be installed to prevent accidental contact with energized equipment.
- Appropriate signs indicating the hazard shall be posted near the barricade or barrier.

(4) Temporary Fence for Underground Cable Construction Works

For underground cable construction and excavation works, pylons and safety barriers shall be placed around all excavation openings to alert and protect the public.

The traffic lanes shall be clearly marked by safety cones, barricades and guide signs to prevent accidents and to ensure quality control of constructing roads.

If an excavation is to remain open and unfilled for long time, the Contractor shall either assign security personnel to the location or cover the opening the trench with steel plates or other appropriate materials to ensure public safety.

(5) Temporary Fence for Overhead Line Works

During lifting or lowering of heavy materials in the vicinity of utility poles or transmission towers, appropriate safety controls such as pylons or safety bars shall be installed to ensure that no personnel enter the area directly beneath the suspended load.

2.2.6 COMMUNITY RELATIONS

Requirement for communication with local society shall be referred to Vol.2A-2_Chapter 16, Vol.3B-2_Chapter 17, Vol.4C-2_Chapter 25.

2.7.6 SAFETY MEASURES FOR EARTHQUAKE AND TSUNAMI

In the event of an earthquake, do not rush outside in panic, but instead, take shelter under a sturdy structure.

When the Contractor are engaged in outdoor work, protect your head and evacuate to an open area.

2.8 FIRE PREVENTION

As the following fire stations are located near the construction site, large-scale firefighting facilities within the site shall not be required.

Main Fire Station	Pokhara Fire Station
Location	Pokhara Metropolitan City



Phone Number	061-520222
Operating Authority	Pokhara Metropolitan City
Operating Hours	24 hours a day, 365 days a year
Travel Time to Site	Approximately 15 minutes

However, to ensure initial response in the event of a fire, the Contractor shall comply with the following requirements.

At least one fire evacuation route shall be provided at the construction site.

During the substation construction phase, portable fire extinguisher and fire blankets shall be equipped on each floor of the building.

All firefighting equipment shall be subject to regular inspections, typically once per month.

CHAPTER 3: EXISTING UNDERGROUND, CONCEALED AND OVERHEAD SERVICES

3.1.3 REQUIREMENTS AND PRECAUTIONS

There are some other utility facilities along the underground cable route, and on the utility pole. The Contractor shall take proper preventive measures by themselves.

- Water Supply : Nepal Water Supply Corporation
- Telephone : Nepal Telecom
- Internet : Many ISPs are there
- Public Road : Road Department and Local Authorities

Location of existing underground facilities such as water pipes and telecommunication lines shall be referred to Drawing No. BIR-XXXXXXXXXXXX.

3.1.3 (7) REQUIREMENTS AND PRECAUTIONS

If there is a possibility that underground installations, such as power cables, are energized with high voltage, work shall only be carried out after the Work Supervisor has confirmed that the cable is de-energized

3.1.3 (14) REQUIREMENTS AND PRECAUTIONS

The following sentence shall be added as Clause 3.1.3 (14).

When backfilling underground facilities, the Contractor shall restore the site to its original condition in accordance with the instructions of the road management authority or other relevant agencies.

3.2.3 (3) REQUIREMENTS AND PRECAUTIONS

Clause 3.2.3 (3) shall be replaced with the following:

As a general rule, when working near energized cables or wires, power must be shut off and the Person in Charge at the site must confirm that they are de-energized before work begins.



If, due to certain circumstances, power cannot be shut off, the target object must be insulated, or a safe distance must be maintained during the work.

In such cases, care must be taken to avoid the risk of electric shock, all contractor personnel must be kept safe, and the provision and use of protective equipment must be strictly enforced.

CHAPTER 5: HOISTING AND RIGGING

5.3.1 (6) PLANNING, INSTALLATION AND REMOVAL

The following sentence shall be added as Clause 5.3.1 (6).

Crane operations must be suspended when the 10-minute average wind speed exceeds 10 m/s.

CHAPTER 6: TEMPORARY WORKS

6.1.1 DESIGN AND PROVISION

The following temporary supporting structures (falsework) shall be eligible for the application of alternative requirements:

- No need for fabrication or design of custom-made structures
- Not subject to temporary support or retention of heavy loads (such as structural components)
- Do not require special considerations for ground conditions or working space
- Can be safely implemented using standard or commercially available components (e.g., steel props, formwork supports)

6.7.7 (4) SAFETY MEASURES

The following sentence shall be added after Clause 6.7.7 (4) (a).

The Contractor shall ensure that all metallic structures in areas where temporary facilities are installed are properly grounded.

CHAPTER 7: EXCAVATION WORKS

7.2 PARTICULAR SAFETY MEASURES

The Contractor may choose either manual or mechanical excavation; however, for excavation works on roads, where there is a high possibility of existing utility equipment such as water pipes, the excavation shall be carried out manually up to the depth at which such installations are likely to be present.

7.6.5 (2) PERSONNEL

The following sentence shall be added as Clause 7.6.5 (2) (c).

Blasting engineers and blasting technicians must hold a national license or an equivalent qualification in the relevant country or in a country approved by the Engineer.



CHAPTER 9: CONCRETE WORKS

9.2.3 (1) SAFETY MEASURES FOR PLACEMENT BY PUMPING

The following sentence shall be added as Clause 9.2.3 (1).

Personnel operating concrete pump trucks must have received training on safe operation.

CHAPTER 10: ELECTRICAL WORKS (ADDITIONAL CHAPTER)

The following clauses and sentences shall be added as safety requirement for electrical works

10.1 SCOPE

This Chapter applies to electrical work carried out during the construction of substations, overhead transmission lines, underground transmission lines, overhead distribution lines, and underground distribution lines. The scope includes equipment installation, wire and cable laying, connection work, testing and commissioning, and control panel wiring.

10.2 APPLICABLE STANDARD

The Contractor shall comply with the following standards for the electrical work.

- NFPA 70E (Electrical Safety in the Workplace)
- OSHA 29 CFR 1910 Subpart S and 1910.147 (LOTO requirements)
- IEC 60364 series (Low-voltage electrical installations)
- IEC 61936-1 (Power installations exceeding 1 kV AC – General requirements)

Compliance with these standards enables international-level management of hazards such as electric shock, arc flash, and equipment malfunction.

10.3 GENERAL SAFETY REQUIREMENTS

- (1) Electrical work shall be carried out only by qualified personnel (holders of national licenses or those who have received formal training).
- (2) The work area shall be clearly demarcated using signs and barricades, and entry by unauthorized persons shall be strictly prohibited.
- (3) Appropriate Personal Protective Equipment (PPE), including insulated tools, insulated gloves, dielectric boots, and face shields, must be used during work.
- (4) All electrical work must be carried out in accordance with a work procedure based on a pre-approved Risk Assessment (RA).

10.4 ENERGY ISOLATION MANAGEMENT (LOTO: LOCKOUT/TAGOUT)

10.4.1 PURPOSE AND APPLICABILITY

All electrical work shall implement LOTO procedures to protect workers from hazards such as accidental energization, residual voltage, or unintended operation of equipment.



If the equipment and facilities are entirely new, with no connection to other power sources or systems and no energized components, the application of LOTO shall not be applied.

However, if any part of the equipment is energized, LOTO shall be applied to that portion, and the Contractor shall ensure worksite safety accordingly.

10.4.2 IMPLEMENTATION PROCEDURE

- (1) Identify the target equipment (circuit breakers, switches, DC sources, Ring Main Unit etc.)
- (2) Completely de-energize the equipment using disconnecting devices
- (3) Apply physical lockout using padlocks or equivalent devices
- (4) Attach a tagout label (indicating worker name, work content, and contact information)
- (5) Verify zero voltage using a voltage detector
- (6) Upon work completion, after the Work Supervisor confirm the evacuation of all workers, testing engineers and their tools, the responsible person shall remove the lock and tag.

10.4.3 ADDITIONAL PROVISIONS

- (1) Each piece of equipment subject to LOTO shall be clearly labelled with a unique identifier such as a number or name.
- (2) When multiple contractors are involved in the same electrical system, a group lockout box capable of accommodating multiple locks shall be used.
- (3) All LOTO records shall be maintained in the site safety file and organized in a manner that allows for audit and verification.

10.5 SAFETY MEASURES FOR SPECIFIC ELECTRICAL WORK

10.5.1 TERMINATION AND CONNECTION OF HIGH- AND EXTRA-HIGH VOLTAGE CABLES

These tasks require complete de-energization of the relevant circuits followed by disconnection, grounding, and application of LOTO procedures. Workers shall wear proper PPEs, and exposed conductors must be properly insulated. A Permit to Work (PTW) must be issued prior to work, and risks and countermeasures must be communicated to all workers.

10.5.2 INSTALLATION AND HIGH VOLTAGE TESTING OF SWITCH GEAR

Handling of switch gear including Gas-Insulated Switchgear (GIS) and Ring Main Unit (RMU) involves risks of gas leaks, electric shock, and arc flash; therefore, the work area must be designated as restricted entry. Clear signage shall be posted during testing, and all energizations shall be performed under the supervision of the responsible person. Especially in case of first energization and high voltage testing, all personnel shall be evacuated in switch gear area except minimum testing engineer. Then testing engineer shall keep a safety distance from tested equipment.

10.5.3 RELAY PROTECTION AND CONTROL PANEL WIRING

LOTO must be applied to DC control sources. To prevent incorrect wiring, a dual-check procedure shall be implemented. During testing, only authorized personnel may access the area, and results shall be documented in test records. The living adjacent facilities shall be clearly indicated and



isolated by insulation sheets or similar material if possible.

10.5.4 LIVE LINE PROXIMITY WORKS (TRANSMISSION AND DISTRIBUTION LINE WORK)

Foundation work and equipment (such as lightning arrestors and cable sealing ends) installation work of special branch tower can be expected to involve live line proximity work.

Heavy machinery such as cranes must maintain a minimum distance of 3.05 meters (10 feet) from energized 132 kV transmission line and 11kV distribution line, the Contractor shall monitor the safety distance during the works.

The heavy machinery must be securely grounded to prevent electric shock, the earth installation must be confirmed by the Work Supervisor before commencing the related work.

For distribution lines operating at 11 kV, any work within 1.5 meters of the energized conductor is considered proximity work, the work must be done by specially trained personnel on high voltage.

10.5.5 DE-ENERGIZATION WORK (TRANSMISSION AND DISTRIBUTION LINE WORK)

Due to risks of electric shock, fall from height, induced voltage, and accidental re-energization, proper work permits (PTW) must be issued and confirmed before starting the work. Where the system has previously been energized, Lockout/Tagout (LOTO) procedures shall be applied, and conductors on both sides of the work zone must be visibly grounded (temporary protective grounds).

Before commencing any electrical work, the absence of voltage shall be verified using an appropriate voltage detector. Once de-energization is confirmed, temporary grounding and short-circuiting devices shall be applied to the conductors, following the principle of "first to apply, last to remove." Only after these safety measures are in place may the work proceed. Upon completion of the work and confirmation that all personnel have vacated the area, the grounding devices shall be safely removed.

10.5.6 LIVE WORK (DISTRIBUTION LINE WORK)

Live work on low-voltage electrical lines (typically up to 1000V AC) shall be permitted only when justified and carried out under strict safety protocols. The following conditions must be met:

Workers must wear Class 0 rubber insulating gloves (rated for up to 1000V AC), leather protector gloves over insulating gloves, Insulated footwear, Arc-rated face shields and flame-resistant clothing.

All work must be performed by qualified and trained electricians who have received specific instruction in live-line working procedures.

10.5.7 CABLE CONNECTION WORK IN UNDERGROUND CABLE MANHOLES

Due to risks of oxygen deficiency, electric shock, and limited evacuation, oxygen concentration must be measured, ventilation provided, and monitoring personnel assigned. LOTO and PTW procedures are mandatory, and emergency response readiness must be ensured.



GENERAL CONDITIONS

GC6.6 FACILITIES FOR STAFF AND LABOUR

The Contractor shall provide worker accommodation and welfare facilities that meet the following requirements:

(1) Worker Accommodation

Function	Requirements
Living Quarters	Adequate space, ventilation, natural lighting, furnished with beds, mattresses, and storage space
Bed Spacing	A minimum distance of 1 meter between beds is generally recommended (to reduce overcrowding and for infection control)
Sanitary Facilities	Toilets and shower facilities (with hot water) shall be provided in each accommodation block
Heating/Cooling	Fans, air conditioners, or heaters shall be provided as necessary
Drinking Water	Safe drinking water shall be supplied at all times in compliance with WHO standards
Security & Safety	Lockable entrances, designated evacuation routes, and fire-fighting equipment must be in place

(2) Welfare Facilities

Function	Requirements
Canteen & Kitchen	Clean dining space and kitchen capable of providing nutritious meals (self-cooking is acceptable)
Rest Area	Sheltered or indoor rest areas for use during work breaks
Medical Facilities	First-aid room equipped with basic medical supplies, medicines, and assigned first-aid personnel
Laundry Facilities	Washing machines or designated hand-washing areas
Hygiene Management	Waste collection points, drainage systems, pest control, and other hygiene-related measures
Communication	Mobile network coverage and Wi-Fi (desirable but not mandatory)

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CHAPTER 25:

SOCIAL AND ENVIRONMENTAL REQUIREMENTS



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CHAPTER 25: Social and Environmental Requirements

The Contractor shall be responsible for the full compliance with the following laws, regulations and / or guidelines, including related by-laws, with respect to the execution of this Project. In addition to the ones listed below, the Contractor shall also comply with any new or amended laws, regulations and / or guidelines for social and environmental safeguards during the execution of this Project.

1. Environment Protection Act, 2076 B.S.
2. National Environmental Policy, 2076
3. Environment Protection Rule, 2077 BS
4. National Environmental Impact Assessment Guidelines, 2050 BS (1993 AD) (2009)
5. JICA Guidelines for Environmental and Social Considerations, 2022 A.D.
6. Land Use Act, 2076
7. Land use Policy of Nepal, 2075
8. Land Acquisition Act, 2034 (1977)
9. Land Acquisition, Rehabilitation and Resettlement Policy 2071
10. Contribution Based Social Security Act 2074
11. Contribution based social Security Regulations, 2075
12. Labour Act, 2074 (2017)
13. Labor Rule, 2075
14. Child Labour (Prohibition and Regulation) Act. 2056
15. Soil and Watershed Conservation Act, 2039 (1982)
16. Water Resources Act, 2049 (1992)
17. Water Resources Regulation, 2050 BS (1993)
18. Solid Waste Management Act, 2068 (2011)
19. Solid Waste Management Regulation, 2070
20. Electricity Act, 2049 (1992)
21. Local Government Operation Act, 2074
22. Electricity Regulation, 2050
23. National Wetlands Policy, 2059 (2003)

The Bidders shall take into consideration in the relevant costs that will be incurred, for the strict adherence to the environmental and social consideration measures, including both mitigation measures and monitoring activities, stipulated in the environmental approvals such as the Initial Environmental Examination Report for this Project, the relevant documents forming part of such



approvals obtained under the above laws/regulations/guidelines with respect to this Project, and the Environmental Management Plan (EMP), which is attached as Annex 1 to this document. When there are discrepancies among the above documents, the EMP in Annex 1 shall prevail.

The Contractor shall submit the draft Construction Environmental Management Plan (CEMP) promptly after succeeding the Bid for review of the Employer and shall obtain approval on the final CEMP by the Employer before physical construction start. The Contractor shall submit the draft CEMP with schedule consideration of procedure until to obtain the approval of the Employer such as review, revise, finalise, etc.

The Contractor shall implement mitigation measures and monitoring based on the CEMP and submit a report to the Employer the progress of CEMP implementation once in a month during construction period. With the progress of work, the CEMP shall be reviewed and revised if required by the Employer.



Annex 1 Environment Management Plan for Distribution Line (DL) Construction

The Environment Management Plan (EMP) in this Annex is prepared based on the “IEE of Construction of 132/11 KV Birauta Substation and 600m underground cable line in Kaligandaki-Pokhara (Lekhanath) 132 kV Transmission Line Project, Kaski District, Gandaki Province, Nepal” (referred to as “the IEE report”) The EMP of the IEE report includes all work items for Substation, Transmission Line, and Distribution line. Therefore, the item of Distribution Line (DL) part was quoted from the IEE report and some parts was modified in this Annex.

The EMP of the IEE report is composed with 2 parts as Augmentation measure for beneficial impact and Mitigation measures for adverse impact. These are prepared for construction and operation phase but the plans for design phase was not prepared but the Sub-project includes design phase. Therefore, the plans for design phase were prepared for the bidding document referring to the other IEE reports for the other projects in Nepal.

1. Purpose of the Environmental Management Plan (EMP)

The purpose of the EMP is to list minimum requirement of social and environment impact mitigation, management and monitoring activities to be implemented during the detailed design phase and the construction phase by the Contractor.

Based on this EMP, and the Mitigation and Monitoring Plan included in the EMP, the Contractor shall prepare the draft Construction Environment Management Plan (draft CEMP) to be included in the Tender document. The Contractor shall take overall responsibility of works on the implementation of mitigation measures stipulated in the CEMP, which will be finalized through review and check by the Employer.

The CEMP shall be reviewed during the Design and Construction Phase among stakeholders to verify that mitigation measure in the CEMP are duly targeted to minimize the negative impact in the project areas and then revised as appropriate. This iterative process shall continue throughout the construction period.

2. Implementation Structure of EMP

The key parties who are responsible for the implementation of EMP are indicated in Table 1.

The Employer is responsible for the implementation of the Project.

The Contractor prepares the CEMP, based on this EMP, and implement the plan.

The Consultant reviews the CEPM and supervise its implementation.

Table -1 Environmental Management Responsibilities

SN	Organization	Roles and Responsibility
1	Employer and its institutional line offices	- The Employer owes the top level responsibility for the implementation, management and supervision of the project including the EMP. - The Project Management Unit (PMU) of the Employer is in charge of the overall management of project design and construction, including internal monitoring of the EMP. The PMU is composed with the project Director (PD), the Project Managers (PMs) of Sub-projects, and the counterpart staff. - The Site Engineer is to be assigned in the PMU, whose responsibility is to act as the construction manager and to supervise the mitigation and monitoring activities of the Contractor at the construction site and



		Office/ Storage/ Camp sites. - Environment and Social Monitoring Unit (ESMU) under the Environmental Social Studies Department (ESSD) of NEA cooperates with PMU and assists any activities on the field, with the general public including local communities. - ESMU also will take independent monitoring of the implementation of EMP by the Contractor to keep transparency and submit the monthly monitoring report to the PMU.
2	The Contractor	- The Contractor is responsible for the implementation of the mitigation and monitoring plan, including opening the window for receiving opinions, complaints and grievances from the stakeholders. - The Contractor prepares the Final Project Design which satisfies the requirements of the EMP included in the Bidding Documents. - The Contractor prepares the Construction Plan including the Safety Management Plan and the updated CEMP with detailed mitigation measures and monitoring plan.
3	The Consultant	- The Consultant is responsible for management of the project implementation, including monitoring of the activities of Contractor. - The Consultant ensures that the EMP is fully implemented by the Contractor, and submits monthly progress reports and Quarterly Reports to PMU of the Employer.

The institutional coordination for the implementation of the EMP/CEMP is shown in Figure-1.

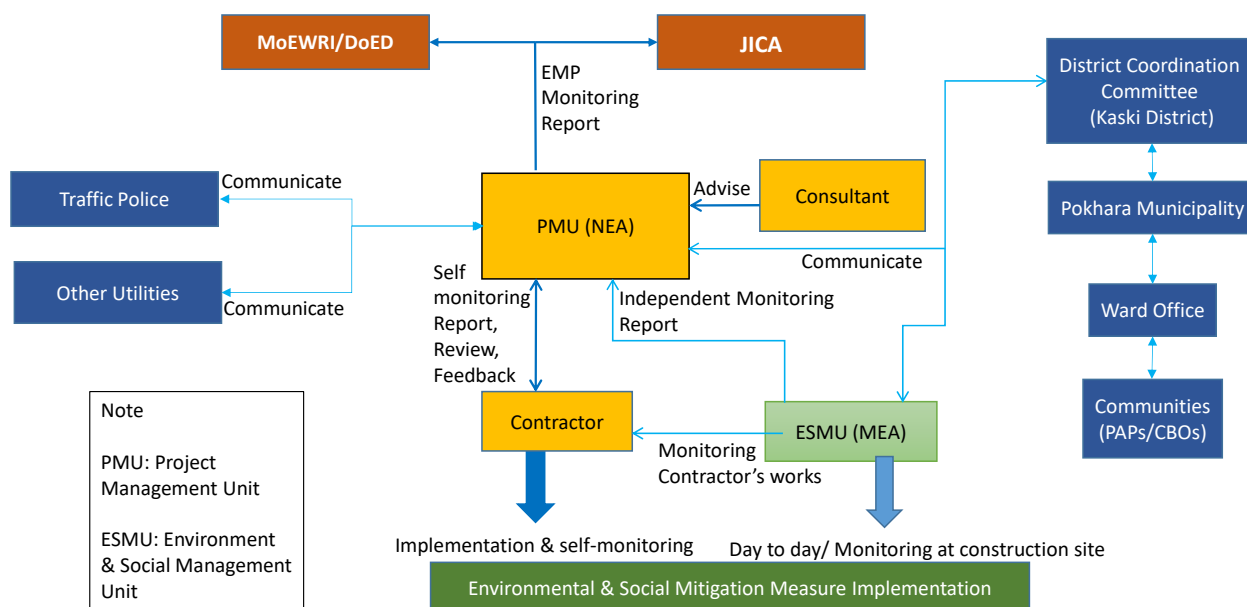


Figure 1 Implementation Structure of Environmental Management Plan

3. Contractor's Environmental Management Unit

During the construction phase, the Contractor shall establish a Contractor's Environmental Management Unit (C's-EMU) for the Sub-project including three parts of Substation, Transmission Line, Distribution Line. And the Contractor shall assign at least one chief officer and one support staff member to the unit. The

chief officer will primarily oversee tasks related to the design and construction of the Sub-station, while the support staff member will focus on activities related to the design and construction of the Transmission and Distribution Lines. Both positions shall be full-time roles, with their primary responsibility being to ensure the proper implementation of the Contractor's Environmental Management Plan (CEMP).

The roles and responsibilities of the C's-EMU shall include, but are not limited to, the following:

- Document construction activities, mitigation measures and environmental incidents by field notes and photographs
- Prepare monthly Environmental Monitoring Report to submit to the Employer
- Arrange training sessions on environmental management, health and sanitation and safety addressed in the CEMP
- Participate in Construction Meetings when necessary
- Communicate with regulatory agencies and key stakeholders
- Provide technical assistance on environmental matters to construction personnel
- Provide recommendations for modifying and/or improving environmental mitigation measures when necessary
- Report spills of hazardous material, accidents, complaints, and other environmental and social incidents

4. Reporting

The Contractor shall provide environmental monitoring report throughout the Design approval stage and Construction Phase, which, at minimum, shall provide the following information:

- A description of ongoing construction activities
- All mitigation measures taken and all monitoring results during the reporting period
- Photos documenting construction activities, environmental issues and corresponding measures

5. Beneficial Enhancement Measures

The Beneficial Enhancement Measures is shown in the Table -2 below.

Table -2 Beneficial Enhancement Measures for Distribution Line (DL) part in Subproject-A (Construction stage)

Environmental domains	Enhancement measures of beneficial impact	What to do	Where to do	How to do	When to do	Who will do
1. Socio-economic and Cultural Environment	1.1 Increase in the Economic Activity within the Project Sites	A total of 80 human resources will be recruited for construction of the project. Support small enterprise development activities suitable to fulfil likely demands from the work force.	Near Project Location	Install the tea or small business at existing shops. Increase agricultural productivities, expansion of new market, business and increase in land value.	Construction Phase	PMU will enhance the activities. Local people will develop their business.
	1.2 Employment Opportunities to the Local People	Hiring both skilled and unskilled labour forces and give daily wages or monthly wages equal to the district official rates.	Project location	Priority of employment opportunities will be provided to project affected families. The project information will be disseminated through pamphlets and other printed materials time to time	Construction Phase	PMU will give guidance to the Contractor. Contractor will assure the prior employment and report to NEA the results.
	1.3 Development of New Skills on the TL Construction	Launch training programs in electro-mechanical works, electric wiring, metal work, tailoring and maintenance of transmission line, underground cable laying and substation to local people to generate semi-skilled manpower.	Project Location	First priority will be given for the project affected people, marginalized community, indigenous people, dalits and local people to the extent they are interested to get involved	Construction Phase	PMU will provide the training to the local people.



6. Environmental Mitigation Plan for adverse impact

6.1 Desing approval phase

The detailed design, which will be prepared by the Contractor must allow for the implementation of the mitigation measures outlined in Chapter 6.2 during the construction phase.

6.1.1 Inventory survey and land acquisition, resettlement

In accordance with the Basic Design which the Consultant prepared, there are no land acquisition and resettlement are expected. Therefore, the Contractor will prepare the detailed design within the given areas which shown in the Basic Design. If any requirements of land acquisition or resettlement, the Contractor shall report and discuss the necessities to the PMU at the very early stage of the design phase.

6.1.2 Coordination with utilities

The Stakeholders' Meeting (SHM) will be held at least once before finalization of the detailed design and once a year by the Employer (PMU). The Contractor shall attend in the SHM, arranged by the Employer (PMU), that invites all relevant utility authorities and any other stakeholders, local communities. The Contractor shall explain the design and the construction plan in the meeting, including the location, duration, and size of the construction works at SHM. Suggestions and inputs obtained in the meeting shall be incorporated in the final design and the construction plan.

The Contractor shall prepare an Emergency Plan that describes the necessary procedures and actions to minimize the negative impact of accidents with water and other utilities.

The Contractor shall set up a compliant desk to receive the opinions and grievances from the local residents and businesses. The desk shall disclose the information of personal names, contact number, address for meeting in person of the desk by publication of the information, i.e. sign boards, flyers, advertisement in newspapers, etc.

6.1.3 Impact on the public/ private trees

In accordance with the Basic Design which the Consultant prepared, tree cutting is not expected. The Contractor shall pay maximum effort to avoid felling public/ private trees in the project areas. If the Contractor will require any tree cutting of both public tree and private tree, the Contractor shall report and discuss the necessities to the PMU at the very early stage of the design phase. In case felling of public/private trees, the Contractor shall assist the Employer in the process of taking due process for permission and paying necessary compensation fee.

6.1.4 Office, storage and camp

The Contractor shall request for the approval of plan for arrangements of office, storage and camp if the Contractor considers these are necessary. However, land acquisition and involuntary resettlement even if temporary, are not permitted.

6.1.5 Informing the construction schedule

The Contractor Shall request the PMU to inform the residents of the construction schedule in writing, at least three weeks before the start of construction. The same applies in case of any changes to the construction schedule. The PMU will inform this to the Ward office(s) at least two weeks before the start of the construction. The Ward office(s) will inform this to the corresponding residents at least one week before the start of the construction. The informing system is shown in the Figure-2.



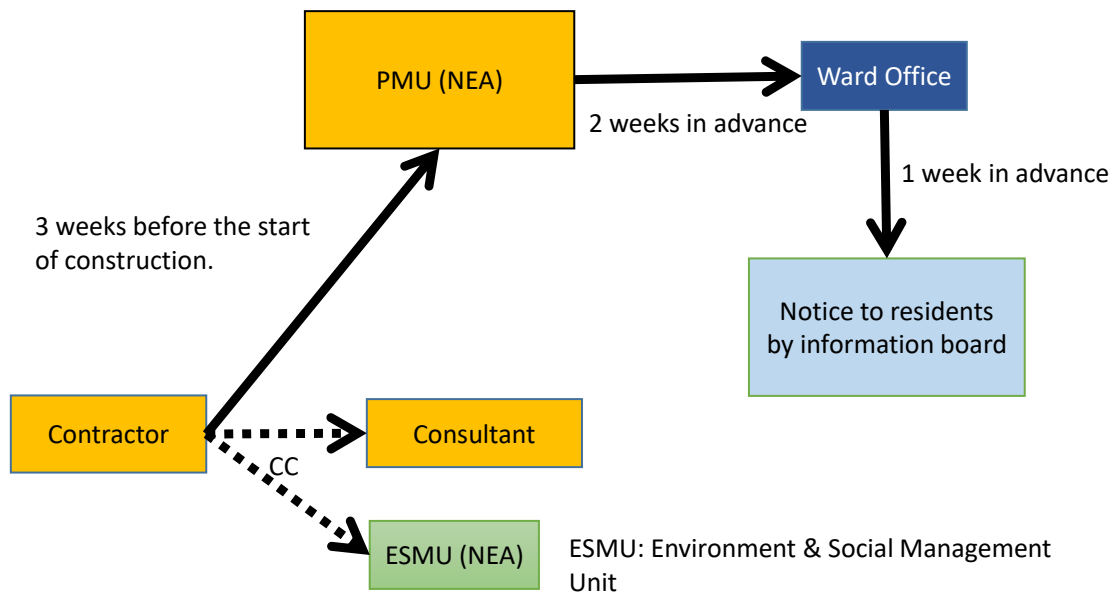


Figure 2 Construction Schedule Informing System

6.2 Construction phase

The Environmental Mitigation Plan is shown in Table-3 below.

Table -3 Environmental Mitigation Plan for DL part (Construction stage)

Environmental domains	Mitigation measures of adverse impact	What to do	Where to do	How to do	Who will do
1. Physical Environment	1.1 Soil/ Top soil cutting and filling	Proper levelling, compaction, conserve top soil and stability of land will be done after excavation during construction of DL.	DL areas	Allowing a short time for the soil to begin drying and then using a bulldozer to smooth and fill in the soil ruts. Identifying site-specific soil characteristics and concerns from the landowner and farm operator before construction begins; Plastic sheets or tarpaulin will be covered on top soil generated during excavation. Soil generated during construction work will be backfilled and compacted. Keep soil heaps away from the edge equivalent to 1.5 m or depth of pit whichever is more. Provide barricade with warning signal with at least two entries/exits.	Contractor
	1.2 Land use change due to DL construction	Construction activities will be done with minimal impact on land use changes.	DL areas	Avoid unstable land and examine carefully before excavations. Avoid unnecessary excavation and limit as mentioned in project design.	Contractor
	1.3 Solid and liquid waste disposal	Control haphazard disposal of solid and liquid wastes from camp sites and construction work site	At active construction works site and camp sites	Provision of separate safe designated storage area for proper management of solid and liquid waste. Provision of timely transportation of solid and liquid waste in designated location specified	Contractor



				by authority. Hazardous materials will be handled carefully and safely as per the manufacturer guidelines and specifications. Hazardous materials shall be stored in secure and bunded areas, and in accordance with manufacturer specifications on structures built within campsite. Immediately contain and mop up will be done for accidental chemical spill.	
	1.4 Occupational health safety (Accident contact with electrical lines)	Provide safety gear to workers, ensure safe working environment.	Construction sites	The construction workforce will be instructed in regards to the occupational health risk of the construction workers on a regular basis. First-aid kits and safety gears will be made available at every working site with the instructions of use. The Contractor must ensure proper safety management to minimize the risk of accidents with residents.	Contractor
	1.5 Temporary air pollution (Due to levelling work, operation of heavy machineries)	Avoid emission of fugitive dust particles due to construction of DL sites. Water will be sprinkled when there is an obvious dust problem on all exposed surfaces to suppress emission of dust.	DL sites, underground cable laying areas and access road	Frequency of sprinkling will be kept such that the dust remains under control in dry seasons. Vehicular movement will be restricted to a specific time for dumping of supplies and construction material. Material loads shall be suitably covered and secured during transportation to prevent the scattering of soil, sand, materials or dust. No burning of waste or construction materials.	Contractor
	1.6 Noise Pollution due to operation of heavy	Anthropogenic noise at the camp sites will be minimized through special instruction to the workforce. In the section of the DL construction	At active construction works site	Provide maintenance of construction machinery/vehicles will be done quarterly. Acoustic barriers/enclosures will be provided to high noise generating machinery where	Contractor



	machineries	around the Ramsar site (Phewa Lake), particular attention must be paid to noise.		applicable. All workers will be provided with earmuffs/plugs. Noise level monitoring will be conducted periodically. Controlling operation time (7a.m.-5p.m.) to reduce impact by noise as much as possible. In case of nighttime construction can not be prevent, the Contractor shall explain the construction schedule in the SHM and inform the schedule to the residents in advance certainly. If any impacts on the wildlife, especially the immigrate birds will be detected, the Contractor shall stop the construction and discuss proper counter measures with PMU.	
	1.7 Impacts on pedestrian and vehicular movement	Prior notification as shown in Figure-2. Proper restoration of soil and construction materials	DL construction sites	Safety signs will be provided in order to reduce potential hazards to pedestrian and vehicular movements. Secure public, local people and entrance of construction site by placing plastic strips, barriers, phosphoric warning lights. In order to facilitate pedestrian, prior notification for each section of DL construction will be provided as shown in Figure-2, for upgrading road and provide support on covering open canal by appropriate measures.	Contractor Contractor, PMU and Ward office(s)
	1.8 Impact due to construction activities (Underground cable laying and tower foundation)	Provide safety equipment and trainings on work site during machinery operations. Proper storage and management of non-hazardous construction waste, toxic waste and liquid waste. Control air pollution with dust emission	DL construction sites	Provision of construction Workers with uniforms and PPE. Allowing only specially trained personnel of controlling machines and provision of labor safety training to all workers prior to machinery operations. Temporary storage of construction waste and	Contractor 

		Control noise generation		toxic wastes in especially allocated bunded/lined areas and formally designed locations within the fenced area of SS and timely disposal of wastes to the formally designed locations. Suppression of dust during machinery activities by ongoing water spraying and prohibit open burning of construction/waste material at the site.	
	1.9 Impact on utilities while DL construction	Careful planning and risk assessment will be done	Underground Cable laying	Soil generated during excavation will be backfilled, proper compaction and restoring as per previous soil conditions Regular, effective maintenance and restoration activities will be done for damaged water supply pipes and other public utilities (if damaged)	Contractor
	Major crossing	None.			
2. Biological Environment	2.1 Disturbance to wildlife habitat, movement, feeding and migratory route	No mitigation measures is required as project area is not considered as critical habitat and no significant impact is expected			
3. Socio-economic and Cultural Environment	3.1 Issues of Loss of Property and Land	The DL will be constructed under or o the public road and no loss of property and land are expected. In case of unexpected loss of property and land, following measure shall be taken properly. Compensate all permanently acquired lands as per rate fixed by Compensation Determination Committee.	DL construction sites	Private land owners will be compensated as per the Land Acquisition Act (1977). Compensation for permanently acquired lands has provided as per the land rate fixed by compensation determination committee. Compensation of a temporary structures has compensated as per rate fixed by compensation determination committee	NEA



				without deducting capital gain tax.	
	3.2 Direct and indirect impacts on Gender, Indigenous, Tribal and Vulnerable Groups	Instruct the workers to respect and behave decently with women	Construction work sites	Priority in employment opportunities to indigenous, vulnerable people based on skills and capacity. Training program will be conducted for marginalized women, indigenous and vulnerable project affected families	NEA will give guidance to the Contractor. The Contractor will follow the guidance.
	3.3 Loss of Standing crops during construction of new tower	The DL will be constructed under or on the public road and no loss of standing crops are expected. In case of unexpected loss of standing crops, following measure shall be taken properly. Compensate the land owners for the loss of crops due to permanent acquisition.	Tower Foundation	Proper compensation will be provided for the loss of crop in private land as per market price.	NEA
	3.4 Community Health and Hygiene	The Contractor shall keep the project area clean and hygienic to ensure the project activities will not cause the spread of communicable diseases. The Contractor shall educate the communities around the sub-project site and construction workers in particular on infectious diseases, including HIV/AIDS.	DL and camp site Construction work sites and surrounding area	The Contractor shall manage solid waste properly and construct adequate toilets to mitigate impact on community health. The Contractor shall provide good quality drinking water in camp site. The Contractor shall conduct regular health checkup during construction of project The Contractor will conduct education program for the communities around the sub-project site and construction workers at least one a year.	Contractor



	3.5 Issues on Law and Order situation (Local safety and security)	Local authorities will be regularly informed about the construction plans, construction sites and other related activities	Construction work sites	Construction workforce will be regularly instructed to respect local people, their traditions and cultures and not to indulge in any conflict with them. Strict code of conduct will be provided. Construction will be stopped immediately if breached laws and order situations and until positive response was received.	PMU (NEA) /Ward office(s)/ Contractor
	3.5 Aesthetic Impacts due to Stockpiling of the Construction Materials	Proper storage of construction materials without aesthetic impact.	Construction sites	Construction materials will be stored in closed area without creating general visual/ aesthetics obstructions Excavation works will be limited only to the required level.	Contractor
	3.6 Impact on existing infrastructures and utilities	Construction activities will be carried out without affecting road and utilities to the extent possible. Early Restoration of the road and public utilities (Drinking water supply) to previous condition.	Construction sites	Underground cable laying will be carried in coordination with local stakeholder, Nepal Water Supply Corporation, Pokhara and Pokhara Metropolitan Office The Contractor will be responsible for repairing any properties damaged during construction of project.	Contractor
	3.7 Grievance Redress Mechanism (GRM)*1	GRM will be secured during the construction phase.	Construction area and surrounding area	NEA will establish the coordination committee*2 to resolve additional issues, queries, and grievances. The Contractor shall keep one compliant desk open of the sub-project area, where includes Substation, Transmission Line and Distribution Line, throughout the construction phase to receive the complains and grievances from local residents and	NEA Contractor



				businesses. The Contractor shall take prompt action to solve raised complaints or to improve accident prevention measures.	

(Note *1) The GRM for any infrastructure project provides an effective approach for complaints and resolution of issues reliably made by the affected community. A grievance redress mechanism will be established to address the social issues associated with the project and look into complaints and concerns from local stakeholders etc. GRM will seek to resolve the issues quickly to expedite project activities.

(Note *2) A coordination committee will be formed comprising of seven members including a member each from Nepal Electricity Authority Substation Officer, Tole development committee, mother's group (Aama Samuha), youth club, and local representatives. Additionally, the project will coordinate with the coordination committee for any activities. In addition to the above, if there are any grievances related to environmental management issues in the project area, grievances and suggestions will be recorded and passed on to the relevant authorities for necessary action and follow-up.

7. Monitoring plan

7.1 Deign approval phase

The Contractor shall monitor the items of the Tables under Chapter 7.1. The Contractor will carry out the items listed in the Tables as common monitoring for the three parts (Substation, Transmission Line and Distribution Line).

7.1.1 Inventory survey

Due to DL will be constructed under or on the public road, no land acquisition is required. Therefore, inventory monitoring is not required. In case of unexpected land acquisition and resettlement will be occurred, the Contractor shall discuss the matters with PMU(NEA) in earlier stage and NEA shall take necessary actions.

7.1.2 Coordination with Utilities, other stakeholders and Local Communities

Table -4 Coordination with Utilities, Stakeholders and Local Communities

S.N	Item	Parameters to be Monitored	Location	Monitoring Frequency
1	Water usage and water right	<u>Meeting with Utilities</u> Attend and record the meetings and discussion with utilities arranged by the Employer.	Sub-Project sites or as per the mutual understanding	At least once before finalization of the design, then once per year
	Disturbance to social infrastructures and services	<u>Emergency Plan</u> Submission of the emergency plan for accidents to the Employer and record of approval.		At least once before finalization of the design, then once per year
	Living environment of residents	<u>Grievance Redness Mechanism</u> Record the information (Name of the person, contact number, address) of the complaint desk to receive the opinions and grievance from the stakeholders. Record of publication of above information about the compliant desk (i.e. photos of sign board, flyers, advertisement in newspapers)		At least once before finalization of the design, then quarterly throughout the Construction phase.
2	Land Acquisition, Resettlement	The DL will be constructed under or on the public road. In case of unexpected land acquisition and resettlement, the Contractor shall record the meetings with stakeholders.	Sub-Project sites or as per the mutual understanding	At least once before finalization of the design.



7.1.3 Coordination on the public/private trees

Table 5 Coordination on Public/Private Trees

S.N	Item	Parameters to be Monitored	Location	Monitoring Frequency
1	Impacts on public/private trees Destruction of landscape	Number of public/private trees planned to be felled Planning of compensatory plantation Permission of felling tree from authority and Record of meeting with relevant authority.	Sub-Project sites	At least once before finalization of the design, then monthly until the end of payment.

7.1.4 Coordination on office, storage and camp

Table 6 Coordination on Office, Storage and Camp

S.N	Item	Parameters to be Monitored	Location	Monitoring Frequency
1	Land Acquisition/ Land Leasing	Land Leasing agreement Observe and record the existence/absence of occupants on the land. In case the potential site had occupants, record	Potential sites for the Office/storage/camp	Until appropriate sites(s) is (are) decided.

7.1.5 Informing the construction schedule

Table 7 Informing the construction schedule

S.N	Item	Parameters to be Monitored	Location	Monitoring Frequency
1	Construction schedule	Official letter asking NEA to inform the construction schedule to the resident through Ward Office(s) Observe and record the public notice(s).	Sub-Project site and surrounding areas. Especially, if the DL will be constructed by section, the residents must be notified through the Ward office of the construction schedule for each section. For this purpose, the Contractor shall submit an official letter to the PMU at least 3 weeks prior to the construction	At least once before physical construction starts, then monthly until the end of payment.



			of the section.	

7.1.6 Baseline monitoring

The baseline monitoring will make a baseline data for comparison with the impact monitoring which will be taken during construction. The baseline monitoring shall be carried out after contract between NEA and the Contractor will be completed and before the physical construction such as civil works will start. The air pollution baseline monitoring will be conducted at one place and the noise pollution baseline monitoring will be done at two places in all construction sites including Substation, Transmission Line, and Distribution Line. The place of monitoring of air pollution will be set at one sensitive area i.e. hospital, temple and school. The places of noise pollution monitoring will be set at sensitive area and urban residential area.

Location and timing of monitoring of air and noise pollution shall be proposed by the Contractor and approved by the Employer.

(Air Pollution monitoring)

- ✧ [Parameters]: PM10, PM2.5, TSP, and CO
- ✧ [Sampling duration]: 24 hours
- ✧ [Reference values]: National ambient air quality standard

Methodology of air sampling for air pollution monitoring is shown below as a reference. The Contractor shall propose appropriate methodology in the tender document.

Item	Parameter			
	PM10	TSP	PM2.5	CO
Unit	(μg/m ³)			
Sampling device	The Contractor shall follow the standard above.			Non-Dispersive InfraRed (NDIR) or electro-chemical sensor can be used.
Vacuum amount	1m ³ air per minute will be vacuumed through filter paper.		1m ³ air per hour will be vacuumed through filter paper.	None
After sampling	Sampling filter paper will be analysed at Labo. The amounts of parameters will be measured.			

(Noise Pollution monitoring)

- ✧ [Required value]: Leq (Equivalent Continuous Sound Level) for every hour and 12 hours of daytime and 12 hours of nighttime.
- ✧ [Sampling duration]: 12 hours of daytime (07:00-21:00), 12 hours of night time (21:00-07:00)
- ✧ [Measurement frequency]: once per 5 seconds
- ✧ [Conversion formula from sound level to Leq]: Energy Averaging formula for sound level

Methodology, device and equipment of noise sampling for noise pollution monitoring shall be proposed by the Contractor in the tender document. The Contractor shall include them in the CEMP after approval by the Employer.

Table 8 Baseline Monitoring

Environment	Types of Monitoring	Monitoring Indicator	Monitoring Methods	Schedule (Time)	Location	Financial commitment	Monitoring responsible
Physical and chemical environment	Land Use change	Cultivable land, barren land, Settlement	Direct observation and consultation with local people	Design approval phase	Tower foundation, Substation and underground cable laying	Included in civil cost	PUM (NEA)
	Air Pollution	CO, PM _{2.5} , PM ₁₀ and TSP	Sample collection and lab analysis Duration is 24 hours.	Design approval phase	One place in project affected areas		Contractor
	Noise pollution	Noise level (Leq) (dB)	Noise level meter Duration is 24 hours.	Design approval phase	Two places in project affected areas		Contractor
Biological Environment	Wild animal status	Status on wild animal accident	Consultation with local people	Design approval phase	Project affected areas		PMU (NEA)
Socio-economic and cultural environment	Loss of land/property	Area of Land/property loss	Records of land/property acquisition	Design approval phase	Substation area		PMU (NEA)
	Cultural and Religious status	Number of cultural and religious sites	Public consultation with local people	Design approval phase	Project affected ward and Pokhara Metropolitan Office		PMU (NEA)
	Socioeconomic condition	Number of Labors and economic status	Direct observation, Consultation with local and relevant stakeholders	Design approval phase	Project affected ward and Pokhara Metropolitan Office		PMU (NEA)
	Community Health	Types of disease, Number of health center	Direct observation, Consultation with local and relevant stakeholders	Design approval phase	Project affected ward and Pokhara Metropolitan Office		PMU (NEA)

7.2 Impact monitoring

The Impact monitoring is the Contractor's own check on the implementation of the Environmental Mitigation Plan set out in Chapter 6 in this document. At the same time, the ESMU independently checks the work of the Contractor on site, prepares an independent monitoring report and submits it to the PMU. The impact monitoring plan is shown in Table 9.

7.3 6.2.3 Every hiring occasion

Table 10 Every Hiring Occasion

S.N	Item	Parameters to be Monitored	Location	Monitoring Frequency
1	Children's right	Check the age of every worker at hiring.	Sub-Project site and surrounding areas.	Daily check and monthly reporting.

Table 9 Impact Monitoring (Construction phase)

Environment	Types of Monitoring	Monitoring Indicator	Monitoring Methods	Schedule (Time)	Location	Monitoring responsible
1, Physical and chemical environment	1.1 Soil/ Top soil cutting and filling	Volume of soil excavated.	Direct observation	Daily observation and monthly reporting during construction	DL construction area	Contractor
	1.2 Land Use	Area of land acquired	Direct observation/ Record of land acquisition	Before physical construction starts	Along DL sites	PMU (NEA)
	1.3 Solid and Liquid Waste Disposal	Disposal pattern/ mechanism/ methods used for solid waste and liquid waste disposal	Direct observation	Daily observation and monthly reporting during construction	DL construction area	Contractor
	1.4 Occupational health safety (Accident contact with electrical lines)	No of Accidents Availability of Nos of First Aid Kits/ safety gear/ Health status of workers	Visual observation, Checking accidental records, Nos of First Aid kits/ Safety gears and records of health status	Daily observation and monthly reporting during construction	DL construction area	Contractor
	1.5 Temporary air pollution (Due to levelling work, operation of Heavy machineries, etc.)	Concentration of CO, PM _{2.5} , PM ₁₀ and TSP No. of Vehicle Movements	Air quality measuring Direct observation/ Vehicle Inspection records/	Once before monsoon (March to May), once after monsoon (October to November) during construction Daily observation and monthly reporting	Sub-Project construction area DL construction area	Contractor



Environment	Types of Monitoring	Monitoring Indicator	Monitoring Methods	Schedule (Time)	Location	Monitoring responsible
	1.6 Noise Pollution due to operation of heavy machineries	Noise Level dB(A)	Noise monitoring Vehicle Inspection records	Once before monsoon (March to May), once after monsoon (October to November) during construction Daily observation and monthly reporting	Sub-Project construction area DL construction area	Contractor
	1.7 Pedestrian and vehicular movements due to underground cable laying.	Safety signage, status of covering open canal of Fewa powerhouse.	Direct observation	Daily observation and monthly reporting during construction	DL construction area	Contractor
	1.8 Impact due to construction activities (Underground cable laying, tower foundation)	Volume of Storage and Handling of SF ₆ gas and other hazardous toxic and liquid waste Nos of safety equipment, Spill kits	Direct observation and Inspection of safe storage and Handling, spill kits	Daily observation and monthly reporting during construction	DL construction area	Contractor
2.0 Biological Environment	2.1 Disturbance to wildlife habitat, movement, feeding and migratory route	Number of hunting, accident of the wildlife.	Community consultations and observation	Every six months	Surrounding DL area	Contractor
3.0 Socio-economic and cultural environment	3.1 Loss of land/property	Area of land and property loss	Interviews, observation, and Land revenue office records observation	Before physical construction starts.	DL construction and surrounding area	PMU (NEA)



Environment	Types of Monitoring	Monitoring Indicator	Monitoring Methods	Schedule (Time)	Location	Monitoring responsible
		Rate fixed by CDC meeting				
	3.2 Impacts on Gender, Indigenous, Tribal and Vulnerable Groups	Number of gender discrimination cases, Number of vulnerable groups, female workers involved in construction sites Construction of separate toilets for male and female	Discussions with the affected communities, parties and records of complaint cases	Before finalization of detailed design, then, every two months during project construction	DL and surrounding area.	Contractor
	3.3 Loss of Standing crops during construction of new tower	Loss of standing crops	Observation and Interview with land owners and records of CDC minute meetings	Before physical construction starts, then once loss will occur during project construction	DL and surrounding area.	PMU (NEA)
	3.4 Community Health and Hygiene	Adequacy of Nos of toilets, first aid kits, drinking water supply and volume of solid wastes. Type of disease and number of communities, people affected	Community consultations, and Checking grievance records	Daily check and monthly reporting during project construction	Project Affected Area of DL	Contractor



Environment	Types of Monitoring	Monitoring Indicator	Monitoring Methods	Schedule (Time)	Location	Monitoring responsible
		Education program for community and workers	Record of program	Once per year at least	Project affected area (sub-project)	
	3.5 Impacts on Law and Order situation	Nos of conflicts and reasons for conflict. Nos of complaints Nos of incidents of law and order break down and reasons	Police records, consultation with the communities, Direct observation	Every six months during project construction Daily check and monthly reporting	Project Affected Area of DL	Contractor
	3.6 Aesthetic Impacts of Stockpiling of the Construction Materials	Construction materials stockpiling	Direct observation	Daily check and monthly reporting during project construction	Project Affected Area of DL	Contractor
	3.7 Impact on existing infrastructures and utilities	Nos of damaged infrastructure and utilities	Direct observation	Daily check and monthly reporting during project construction	Project Affected Area of DL	Contractor

8. Monitoring form

The Contractor shall implement the environmental management measures described in the CEMP and voluntarily monitor the results. The forms for recording the monitoring results are described below, and the Contractor should propose the monitoring forms for all monitoring items based on these. The following forms may have some shortcomings, but the Contractor should make up for them and submit a proposal with appropriate details.

8.1 Design Approval Phase

8.1.1 Inventory survey

Week	Reporting Date	Finished length a (km)	Finished% b = a (km)/ total length (km)	Remaining length c = total length (km) - a (km)
1				
2				
3				
4				
5				

8.1.2 Coordination with utilities, other stakeholders and local communities

Week	Dates			Record - Objectives - Main points of discussions, decisions	Recorded by (Name)
	Meeting	Emergency Plan	GRM	- Attendants - Venue	
1					
2					
3					
4					
5					

8.1.3 Coordination on the public/ private trees

Week	Dates	Record	Recorded by (Name)
1			
2			
3			
4			
5			

8.1.4 Coordination on office, storage, and camp

Item	Parameters to be Monitored	Location	Timing/ Frequency
Land Acquisition, Resettlement / Land leasing	1. Observe and record the existence/absence of occupants on the land. 2. In case the first potential site had occupants, record all the negotiation process with the Employer until suitable site is officially allocated.	Potential site for the Office/ Storage/ Camp sites	Until suitable site(s) is (are) decided
Date (DDMMYYYY)	Location and existence/absence of occupants	If occupants exists, what is the next step?	Recorded by (Name)

8.1.5 Informing the construction schedule

Week	Dates	Record Construction place(s), target ward(s), Ref. No. of Letter to PMU	Recorded by (Name)
1			
2			
3			
4			
5			

8.1.6 Baseline monitoring (Contractor's responsibility parts only)

(Air pollution monitoring)

Monitoring form: Air pollution monitoring (Baseline monitoring)			
Season, Date/month/year: before/after monsoon, xx/xx/xx			
Time of monitoring:			
Recorded by (Name):			
Place (Name and coordinate):			
Monitoring results			
Name and Address of Labo			
PM2.5 (μ g/m ³)	PM10 (μ g/m ³)	TSP (μ g/m ³)	CO (μ g/m ³)

Note: Report by Labo shall be attached.



(Noise monitoring)

Monitoring form: Noise pollution monitoring (Baseline)-No.1			
Season, Date/month/year: before/after monsoon, xx/xx/xx			
Time of monitoring:			
Recorded by (Name):			
Place (Nama and coordinate):			
Monitoring results			
Daytime		Nighttime	
Time	Noise (Leq)	Time	Noise (Leq)
07:00-08:00		19:00-20:00	
08:00-09:00		20:00-21:00	
09:00-10:00		21:00-22:00	
10:00-11:00		22:00-23:00	
11:00-12:00		23:00-24:00	
12:00-13:00		24:00-01:00	
13:00-14:00		01:00-02:00	
14:00-15:00		02:00-03:00	
15:00-16:00		03:00-04:00	
16:00-17:00		04:00-05:00	
17:00-18:00		05:00-06:00	
18:00-19:00		06:00-07:00	
07:00-21:00		19:00-07:00	

Note: Raw data (measurement of every 5second) and calculation results of Leq shall be attached.

Monitoring form: Noise pollution monitoring (Baseline)-No.2			
Season, Date/month/year: before/after monsoon, xx/xx/xx			
Time of monitoring:			
Recorded by (Name):			
Place (Nama and coordinate):			
Monitoring results			
Daytime		Nighttime	
Time	Noise (Leq)	Time	Noise (Leq)
07:00-08:00		19:00-20:00	
08:00-09:00		20:00-21:00	
09:00-10:00		21:00-22:00	
10:00-11:00		22:00-23:00	
11:00-12:00		23:00-24:00	
12:00-13:00		24:00-01:00	
13:00-14:00		01:00-02:00	
14:00-15:00		02:00-03:00	
15:00-16:00		03:00-04:00	
16:00-17:00		04:00-05:00	
17:00-18:00		05:00-06:00	
18:00-19:00		06:00-07:00	
07:00-19:00		19:00-07:00	

Note: Raw data (measurement of every 5second) and calculation results of Leq shall be attached.



8.2 Impact monitoring

8.2.1 Record of the machineries and vehicles

Record:	(DDMMYYYY)	At the start of the construction works	Quarterly
Recorded by:	Name	Position	
Site:			

Serial Number	Types of Utilized Machinery, Vehicle	Number of same type		Total	% of Low-emission Type
		Low-emission type	Ordinary type		
		a	b	c=a+b	d= a/c*100
1					
2					
3					
4					

Add lines when necessary.

8.2.2 At the start of the construction works with follow-ups

Item ID	Item	Parameters to be Monitored	Location	Timing/Frequency
2.1	Disturbance e of wildlife habitat, movement, feeding, and migratory route	Number of hunting, accident of the wildlife	Surrounding DL sites	Every six months
3.2	Impacts on gender, indigenous, tribal and vulnerable groups	Number of gender discrimination cases. Number of vulnerable groups, female workers Number of separate toilets for male and female	Ditto	Before finalization of detailed design, then, every two months
3.4	Community health and hygiene	Record of education programs	Surrounding sub-project area	Once a year
3.5	Impacts on law and order situation	Police records shall be obtained and reported every six months. Once any incident happens, daily record shall be reported.	Surrounding DL sites	Every six months
S.N.	Date (DDMMYYYY)	Actions taken	Next date for action	Recorded by (Name)
1				



2				
3				
4				
5				
6				

8.2.3 Everyday patrol, observation, and recording during the Construction Works

Date:		Findings (Enter either 'Approved' or 'Need action')			Record of conditions	Actions taken	Recorded by (Name)
Item ID	Parameters	T/L construction sites	(Boeng Salang Channel)	Office/ Storage/ Camp sites			
1.1	Volume of soil excavated Mud spills out of the site						
1.3	Disposal pattern/ mechanism/ methods used for solid waste and liquid waste disposal						
1.4	No. of accidents, Accidental record Nos of aid its/ safety gear/ health status of workers						
1.5	Visible dust, emission gas						
1.6	Noise condition						
1.7	Safety signage status of covering open canal						
1.8	Volume of storage and handling of SF6 gas and other hazardous toxic and liquid waste						
3.4	Adequacy of Nos of toilets, first aid kits, drinking water supply and volume of waste at community constructions. Record of grievance Record of types of disease and number of						



	communities, people affected						
3.5	Nos of conflicts and reasons for conflict. Nos of complaints Nos of incidents of law and order break down and reasons						
3.6	Construction materials stockpiling						
3.7	Nos of damaged infrastructure and utilities						
All items	Any accident or near-accident occurrences Received opinions and grievances						
All items	Sanitary condition						
All items	Stagnant water						
All items	Work accidents or spread of infectious diseases among workers						

Copy the table every day.

8.2.4 Monitoring forms of Air and Noise pollution monitoring

Monitoring form: Air pollution monitoring (Impact monitoring)			
Season, Date/month/year: before/after monsoon, xx/xx/xx			
Time of monitoring:			
Recorded by (Name):			
Place (Nama and coordinate):			
Monitoring results			
Name and Address of Labo			
PM2.5 ($\mu\text{g}/\text{m}^3$)	PM10 ($\mu\text{g}/\text{m}^3$)	TSP ($\mu\text{g}/\text{m}^3$)	CO ($\mu\text{g}/\text{m}^3$)

Note: Report by Labo shall be attached.

(Noise monitoring)

Monitoring form: Noise pollution monitoring (impact monitoring)-No.1			
Season, Date/month/year: before/after monsoon, xx/xx/xx			
Time of monitoring:			
Recorded by (Name):			
Place (Nama and coordinate):			
Monitoring results			
Daytime		Nighttime	
Time	Noise (Leq)	Time	Noise (Leq)
07:00-08:00		19:00-20:00	
08:00-09:00		20:00-21:00	
09:00-10:00		21:00-22:00	
10:00-11:00		22:00-23:00	
11:00-12:00		23:00-24:00	
12:00-13:00		24:00-01:00	
13:00-14:00		01:00-02:00	
14:00-15:00		02:00-03:00	
15:00-16:00		03:00-04:00	
16:00-17:00		04:00-05:00	
17:00-18:00		05:00-06:00	
18:00-19:00		06:00-07:00	
07:00-21:00		19:00-07:00	

Note: Raw data (measurement of every 5second) and calculation results of Leq shall be attached.

Monitoring form: Noise pollution monitoring (Impact monitoring)-No.2			
Season, Date/month/year: before/after monsoon, xx/xx/xx			
Time of monitoring:			
Recorded by (Name):			
Place (Nama and coordinate):			
Monitoring results			
Daytime		Nighttime	
Time	Noise (Leq)	Time	Noise (Leq)
07:00-08:00		19:00-20:00	
08:00-09:00		20:00-21:00	
09:00-10:00		21:00-22:00	
10:00-11:00		22:00-23:00	



11:00-12:00		23:00-24:00	
12:00-13:00		24:00-01:00	
13:00-14:00		01:00-02:00	
14:00-15:00		02:00-03:00	
15:00-16:00		03:00-04:00	
16:00-17:00		04:00-05:00	
17:00-18:00		05:00-06:00	
18:00-19:00		06:00-07:00	
07:00-19:00		19:00-07:00	

Note: Raw data (measurement of every 5second) and calculation results of Leq shall be attached.



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PART 2C

EMPLOYER'S REQUIREMENTS FOR

DISTRIBUTION LINE WORK

APPENDIX - C1: TECHNICAL PARTICULARS



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APPENDIX-C1: GUARANTEED TECHNICAL PARTICULARS

Table of Contents

CLAUSE NO.	TITLE	PAGE NO.
1.	11 KV XLPE POWER CABLE, 3 CORE, 400 SQ. MM AL. CONDUCTOR, XLPE & ACCESSORIES	1
2.	11 KV XLPE POWER CABLE, 3 CORE, 300 SQ. MM AL. CONDUCTOR, XLPE & ACCESSORIES	4
3.	11 KV XLPE POWER CABLE, 3 CORE, 150 SQ. MM AL. CONDUCTOR, XLPE & ACCESSORIES	7
4.	11 KV XLPE INSULATED ALL ALUMINIUM ALLOY CONDUCTOR (AAAC).....	10
5.	MULTIPLE CORE LT XLPE ARMOURED CABLES.	13
6.	LT XLPE ARMOURED SERVICE CABLES	16
7.	11KV OUTDOOR TERMINAL KIT	19
8.	HDPE PN6 PIPE (FOR HDD METHOD)	20
9.	HDPE PN4 PIPE (FOR OPEN TRENCH)	21
10.	11KV SF6 EXTENSIBLE RMU.....	22
11.	LT FEEDER PANEL WITH MULTI-FUNCTIONAL METER.....	31
12.	11M STEEL TUBULAR POLE	33
13.	9M STEEL TUBULAR POLE	35
14.	GANG OPERATED SWITCH	37
15.	LIGHTNING ARRESTOR	39
16.	POLE CLAMPS	40
17.	EARTH RODS AND CLAMPS	41
18.	GROUNDING CONDUCTOR	42
19.	GALVANIZED STEEL NUTS AND BOLTS	43
20.	HIGH VOLTAGE WARNING/DANGER PLATE	44
21.	RTU (REMOTE TERMINAL UNIT).....	45



22.	FRTU (FEEDER REMOTE TERMINAL UNIT).....	55
23.	SDH/MPLS SWITCHABLE OPTICAL TERMINAL.....	63
24.	UNDERGROUND FIBER OPTIC CABLE (UGFO) – 24 FIBERS.....	68
25.	UNDERGROUND FIBER OPTIC CABLE (UGFO) – 96 FIBERS.....	69
26.	DUAL-WINDOW SINGLE MODE (DW-SM).....	70



1. 11 KV XLPE POWER CABLE, 3 CORE, 400 SQ. MM AL. CONDUCTOR, XLPE & ACCESSORIES

No.	DESCRIPTION	UNIT	NEA REQ.	DATA to be Filled
			11 kV	11 kV
1	Manufacturer and Country of Origin			
2	Year of manufacturing experience	Years	10	
3	Catalogue/drawing submitted		Yes	
4	Applicable standard		IEC	
5	Type			
7	Number of Cores	No.	3	
8	Rated Voltage	kV	6/10	
9	Maximum System voltage	kV	12	
10	Max. Rated Voltage between conductor and screen	kV	6.9	
11	Rated Voltage between two conductors	kV	11	
12	Conductor Material		Aluminum	
13	Cross section of the Conductor	mm ²	400	
14	Cross section of each wire	mm ²		
15	No.& diameter of wire in each conductor	No./mm		
16	Class of Stranding		Class 2	
17	Operating Capacitance	μF/km		
18	Maximum Conductor Temperature	°C	90	
19	Conductor screen material			
20	Thickness of Conductor Screen	mm	0.6	
21	Thickness of XLPE insulation	mm	3.4	
22	Insulation screen material			
23	Thickness of Insulation Screen	mm	0.7	
24	Water Swelleable tape	Yes/No	Yes	



25	Copper tape along with copper wire	Yes/No	Yes	
26	Thickness of Copper Screen	mm	0.1	
27	Nominal Thickness of PVC Inner sheath	mm		
28	Copper Screen with water tight design	Yes/No	Yes	
29	Armour Material and thickness			
30	Nominal Thickness of HDPE Outer Sheath	mm		
31	Overall Diameter of the Cable	mm		
32	Continuous current rating at 45 deg. C. ambient			
	- in ground	A		
	- in duct	A		
33	Short circuit current			
	- 0.1 sec	kA		
	- 1.0 sec (minimum kA)	kA		
34	Electrical parameter			
	- Resistance/km			
	- Reactance/km			
	- Capacitance/km			
35	Max. Partial Discharge			
36	AC Test Voltage for 5 min.	kV		
37	Insulation Level:			
	-Power frequency Withstand Voltage	kV		
	-Impulse Withstand, Crest	kV		
38	Min. Insulation Resistance	ohms		
39	Max. Conductor DC Resistance at 20 Deg. C	Ohm/km		
40	Geometric Mean Radius (GMR) of the Cable/Conductor	mm		
41	Fire resistance treated	Yes/No		
42	Is manufacturer an ISO 9001 holder?	Yes/No	Yes	



43	ISO 9001 (with design) certificate submitted?	Yes/No	Yes	
44	Type test certificate submitted?	Yes/No	Yes	
45	User's certificate submitted?	Yes/No	Yes	
46	Standard drum length	Meter		
47	Approx. Net Weight per Meter of cable	Kg		
48	Net weight of cable in drum	Kg		
	Straight Through Joint			
49	Manufacturer and Country of Origin			
50	Year of manufacturing experience	Years	10	
51	Catalogue Number			
52	Copies of Governing Standards Attached		Yes	
53	Applicable standard		IEC	
54	Copies of type test attached	Yes/No	Yes	
55	Type			
56	Is Splice Kit Performed or Tape			
57	Splicing voltage level	kV	12	
58	Power frequency withstand voltage	kV	21	
59	Impulse withstand voltage (BIL)	KV	75	
60	Is ISO 9001 certificate submitted?	Yes/No	Yes	
61	Technical literature/drawings submitted?	Yes/No	Yes	
62	Embossing			

2. 11 KV XLPE POWER CABLE, 3 CORE, 300 SQ. MM AL. CONDUCTOR, XLPE & ACCESSORIES

	DESCRIPTION	UNIT	NEA REQ.	DATA to be Filled
1	Manufacturer and Country of Origin			
2	Year of manufacturing experience	Years	10	
3	Catalogue/drawing submitted		Yes	
4	Applicable standard		IEC	
6	Type			
7	Number of Cores	No.	3	
8	Rated Voltage	kV	6/10	
9	Maximum System voltage	kV	12	
10	Max. Rated Voltage between conductor and screen	kV	6.9	
11	Rated Voltage between two conductors	kV	11	
12	Conductor Material		Aluminum	
13	Cross section of the Conductor	mm ²	300	
14	Cross section of each wire	mm ²		
15	No.& diameter of wire in each conductor	No./mm		
16	Class of Stranding		Class 2	
17	Operating Capacitance	μF/km		
18	Maximum Conductor Temperature	°C	90	
19	Conductor screen material			
20	Thickness of Conductor Screen	mm	0.6	
21	Thickness of XLPE insulation	mm	3.4	
22	Insulation screen material			
23	Thickness of Insulation Screen	mm	0.7	
24	Water Swellable tape	Yes/No	Yes	
25	Copper tape along with copper wire	Yes/No	Yes	



26	Thickness of Copper Screen	mm	0.1	
27	Nominal Thickness of PVC Inner sheath	mm		
28	Copper Screen with water tight design	Yes/No	Yes	
29	Armour Material and thickness			
30	Nominal Thickness of HDPE Outer Sheath	mm		
31	Overall Diameter of the Cable	mm		
32	Continuous current rating at 45 deg. C. ambient			
	- in ground	A		
	- in duct	A		
33	Short circuit current			
	- 0.1 sec	kA		
	- 1.0 sec (minimum kA)	kA		
34	Electrical parameter			
	- Resistance/km			
	- Reactance/km			
	- Capacitance/km			
35	Max. Partial Discharge			
36	AC Test Voltage for 5 min.	kV		
37	Insulation Level:			
	-Power frequency Withstand Voltage	kV		
	-Impulse Withstand, Crest	kV		
38	Min. Insulation Resistance	ohms		
39	Max. Conductor DC Resistance at 20 Deg. C	Ohm/km		
40	Geometric Mean Radius (GMR) of the Cable/Conductor	mm		
41	Fire resistance treated	Yes/No		
42	Is manufacturer an ISO 9001 holder?	Yes/No	Yes	
43	ISO 9001 (with design) certificate submitted?	Yes/No	Yes	



44	Type test certificate submitted?	Yes/No	Yes	
45	User's certificate submitted?	Yes/No	Yes	
46	Standard drum length	Meter		
47	Approx. Net Weight per Meter of cable	Kg		
48	Net weight of cable in drum	Kg		
	Straight Through Joint			
49	Manufacturer and Country of Origin			
50	Year of manufacturing experience	Years	10	
51	Catalogue Number			
52	Copies of Governing Standards Attached		Yes	
53	Applicable standard		IEC	
54	Copies of type test attached	Yes/No	Yes	
55	Type			
56	Is Splice Kit Performed or Tape			
57	Splicing voltage level	kV	12	
58	Power frequency withstand voltage	kV	21	
59	Impulse withstand voltage (BIL)	KV	75	
60	Is ISO 9001 certificate submitted?	Yes/No	Yes	
61	Technical literature/drawings submitted?	Yes/No	Yes	
62	Embossing			

3. 11 KV XLPE POWER CABLE, 3 CORE, 150 SQ. MM AL. CONDUCTOR, XLPE & ACCESSORIES

No.	DESCRIPTION	UNIT	NEA REQ.	DATA to be Filled
1	Manufacturer and Country of Origin			
2	Year of manufacturing experience	Years	10	
3	Catalogue/drawing submitted		Yes	
4	Applicable standard		IEC	
6	Type			
7	Number of Cores	No.	3	
8	Rated Voltage	kV	6/10	
9	Maximum System voltage	kV	12	
10	Max. Rated Voltage between conductor and screen	kV	6.9	
11	Rated Voltage between two conductors	kV	11	
12	Conductor Material		Aluminum	
13	Cross section of the Conductor	mm ²	150	
14	Cross section of each wire	mm ²		
15	No.& diameter of wire in each conductor	No./mm		
16	Class of Stranding		Class 2	
17	Operating Capacitance	μF/km		
18	Maximum Conductor Temperature	°C	90	
19	Conductor screen material			
20	Thickness of Conductor Screen	mm	0.6	
21	Thickness of XLPE insulation	mm	3.4	
22	Insulation screen material			
23	Thickness of Insulation Screen	mm	0.7	
24	Water Swellable tape	Yes/No	Yes	
25	Copper tape along with copper wire	Yes/No	Yes	



26	Thickness of Copper Screen	mm	0.1	
27	Nominal Thickness of PVC Inner sheath	mm		
28	Copper Screen with water tight design	Yes/No	Yes	
29	Armour Material and thickness			
30	Nominal Thickness of HDPE Outer Sheath	Mm		
31	Overall Diameter of the Cable	Mm		
32	Continuous current rating at 45 deg. C. ambient			
	- in ground	A		
	- in duct	A		
33	Short circuit current			
	- 0.1 sec	kA		
	- 1.0 sec (minimum kA)	kA		
34	Electrical parameter			
	- Resistance/km			
	- Reactance/km			
	- Capacitance/km			
35	Max. Partial Discharge			
36	AC Test Voltage for 5 min.	kV		
37	Insulation Level:			
	-Power frequency Withstand Voltage	kV		
	-Impulse Withstand, Crest	kV		
38	Min. Insulation Resistance	Ohms		
39	Max. Conductor DC Resistance at 20 Deg. C	Ohm/km		
40	Geometric Mean Radius (GMR) of the Cable/Conductor	Mm		
41	Fire resistance treated	Yes/No		
42	Is manufacturer an ISO 9001 holder?	Yes/No	Yes	
43	ISO 9001 (with design) certificate submitted?	Yes/No	Yes	



44	Type test certificate submitted?	Yes/No	Yes	
45	User's certificate submitted?	Yes/No	Yes	
46	Standard drum length	Meter		
47	Approx. Net Weight per Meter of cable	Kg		
48	Net weight of cable in drum	Kg		
	Straight Through Joint			
49	Manufacturer and Country of Origin			
50	Year of manufacturing experience	Years	10	
51	Catalogue Number			
52	Copies of Governing Standards Attached		Yes	
53	Applicable standard		IEC	
54	Copies of type test attached	Yes/No	Yes	
55	Type			
56	Is Splice Kit Performed or Tape			
57	Splicing voltage level	kV	12	
58	Power frequency withstand voltage	kV	21	
59	Impulse withstand voltage (BIL)	KV	75	
60	Is ISO 9001 certificate submitted?	Yes/No	Yes	
61	Technical literature/drawings submitted?	Yes/No	Yes	
62	Embossing			

4. 11 KV XLPE INSULATED ALL ALUMINIUM ALLOY CONDUCTOR (AAAC)

No.	Description	Unit	NEA REQ.	DATA to be Filled 100 mm2
1	Manufacturer s Name & Address			
2	Minimum Year of manufacturing experience	Years	10	
3	List of Standard Applicable			
4	Rated Voltage	kV	11	
5	Conductors			
	a. Material		Aluminium	
	b. Actual Area	mm2		
	c. Stranding & wire diameter	Nos / mm		
	d. Approximate overall diameter	mm		
	e. Approximate weight	kg/km		
	f. Maximum Calculated D.C. resistance at 20°C	Ohms/km		
	g. Approximate calculated breaking load	kN		
	h. Reactance			
	i. Current Rating	Amps		
	j. Lay ratio			
	k. Direction of lay			
6	Wire (strand) used in the construction of conductors			
	a. Nominal Diameter	mm		
	b. Maximum Diameter	mm		
	c. Cross-section area of nominal diameter wire	mm2		
	d. Weight	kg/km		
	e. Maximum Calculated D.C. resistance at 20°C			
	f. Minimum breaking load after stranding	kN		



7	Insulation (Semi-conduction screen)			
	a. Material			
8	Insulation (Inner layer)			
	a. Material		XLPE	
	b. Nominal thickness	mm		
	c. Carbon Content	%		
9	Insulation (Outer layer)			
	a. Material			
	b. Nominal thickness	mm		
	c. Carbon Content	%		
10	Combined insulation i.e. both layers			
	a. Minimum thickness	mm		
	b. Min. Tensile strength of insulation	N/mm ²		
	c. Elongation	min		
	Volume resistivity At room temperature of 027-cm) At 70 -cm)			
	Hot set Max. Elongation underload Max. Permanent elongation	%		
	f. AC Test Voltage for 5 min.	kV		
11	Covered Conductor			
	a. Minimum Breaking Strength	kN		
	b. Short time current rating: 1 sec	kA		
	c. Maximum conductor operating temperature i. Continuous operation ii. Emergency operation iii. Short circuit operation; 5 sec	Deg C		
	d. Overall diameter (mm)			

	e. Approximate weight of complete cable	(kg/km)		
	f. Maximum DC resistance of conductor at 20°C			
	g. Reactance			
12	Size of cable drum			
13	Approximate Length of conductor per drum (km ± %)			

5. MULTIPLE CORE LT XLPE ARMoured CABLES.

No.	PARTICULARS		LT XLPE armoured cable		
			3.5Cx300	3.5Cx185	3.5Cx95
1	Manufacturer's name and works address				
2	Standard specification to which the material shall				
3	VOLTAGE GRADE.				
4	NO. OF CORES.				
5	CONDUCTOR DETAILS:				
	A	Normal cross section area of :			
		Phase Conductor (Sq.mm)			
		Neutral Conductor (Sq.mm)			
	B	No. and size of strands (in mm) of:			
		Phase Conductor (Sq.mm)			
		Neutral Conductor (Sq.mm)			
	C	SHAPE OF CONDUCTOR			
	D	Whether compacted or non-compacted			
	E	DC Resistance at 20 0c			
		Phase Conductor ohm/km			
		Neutral Conductor ohm/km			
6	INSULATION				
	1	Type			
	2	Colour			
	3	Thickness			
	A	Phase Conductor (sq.mm)			
		Nominal (mm)			
		Minimum (mm)			
	B	Neutral Conductor (Sq.mm)			

		Nominal (mm)			
		Minimum (mm)			
	C	Fictitious dia of core (mm)			
7	Type of inner sheathing and colour				
	Fictitious dia over laid up cores				
	Thickness of inner sheath				
	Fictitious dia over inner sheath				
8	Whether Binder Tape provided				
9	Armoring				
	A	Type			
	B	Dimension (mm)			
	C	Fictitious dia over armour			
10	Outer Sheath				
	A	Material			
	B	Thickness			
		Nominal (mm)			
		Minimum (mm)			
	C	Standard to which it Confirm			
11	A	Type and size of filler used			
	B	Min. Wt. Of filler in KG./KM			
12	Approx. Overall diameter of the cable in mm.				
13	Nature of Packing.				
14	DRUM				
	A	Tare weight of drum			
	B	Standard specification			
	C	Drum details & dimensions			

	D	Whether 2-Full Ply Flange Construction or 2-Full Ply plus 1 Segmental layer Flange Construction.			
15	Embossing				

6. LT XLPE ARMoured SERVICE CABLES

No	PARTICULARS		Service cable				
			2Cx6	2Cx10	2Cx35	3Cx25+16	3Cx70+35
1	Manufacturer's name and works						
2	Standard specification to which the material shall confirm						
3	Voltage Grade.						
4	No. Of Cores.						
5	Conductor Details:						
	A	Normal cross section area of :					
		Phase Conductor (Sq.mm)					
		Neutral Conductor (Sq.mm)					
	B	No. and size of strands (in					
		Phase Conductor (Sq.mm)					
		Neutral Conductor(Sq.mm)					
	C	SHAPE OF CONDUCTOR					
	D	Whether compacted or non-compacted					
	E	DC Resistance at 20 0c					
		Phase Conductor ohm/km					
		Neutral Conductor ohm/km					
6	INSULATION						
	1	Type					
	2	Colour					
	3	Thickness					
	A	Phase Conductor (sq.mm)					
		Nominal (mm)					
		Minimum (mm)					



	B	Neutral Conductor (Sq.mm)					
		Nominal (mm)					
		Minimum (mm)					
	C	Fictitious dia of core (mm)					
7	Type of inner sheathing and colour						
	Fictitious dia over laid up cores						
	Thickness of inner sheath						
	Fictitious dia over inner sheath						
8	Whether Binder Tape provided						
9	Armoring						
	A	Type					
	B	Dimension (mm)					
	C	Fictitious dia over armour					
10	Outer Sheath						
	A	Material					
	B	Thickness					
		Nominal (mm)					
		Minimum (mm)					
	C	Standard to which it Confirm					
11	A	Type and size of filler used					
	B	Min. Wt. Of filler in KG./KM					
12	Approx. Overall diameter of the cable in mm.						
13	Nature of Packing.						
14	DRUM						
	A	Tare weight of drum					
	B	Standard specification					
	C	Drum details & dimensions					



	D	Whether 2-Full Ply Flange Construction or 2-Full Ply plus 1 Segmental layer Flange Construction.					
15		Embossing					

7. 11KV OUTDOOR TERMINAL KIT

	DESCRIPTION	UNIT	NEA REQ	DATA to be Filled
1	Manufacturer and Country of Origin			
2	Year of manufacturing experience	Years	10	
3	Catalogue Number			
4	Applicable standard		IEC	
6	Type		Heat Shrinkable	
7	Copies of type test Attached			
8	Stress relief performed	Yes/No		
9	Terminator insulation level	kV		
10	Insulation Material		XLPE	
11	Maximum design voltage	kV	12	
12	Impulse withstand voltage (BIL)	kV		
13	Installation Instruction attached	Yes/No	Yes	
14	Fire resistance treated	Yes/No	Yes	
15	Smoke resistance treated	Yes/No	Yes	
16	Is ISO 9001 certificate submitted?	Yes/No	Yes	
17	Technical literature/drawings submitted?	Yes/No	Yes	

8. HDPE PN6 PIPE (FOR HDD METHOD)

	DESCRIPTION	UNIT	NEA REQ		DATA to be Filled
			160mm dia	125mm dia	
1	Manufacturer and Country of Origin				
2	Applicable standard				
3	Type		HDPE PN6	HDPE PN6	
4	PE grade				
5	diameter of the pipe	mm			
6	Wall Thickness	mm			
7	Weight	kg/mtr			
8	Technical Literature submitted	Yes/No	Yes	Yes	
9	Type test certificate submitted	Yes/No	Yes	Yes	
10	Technical literature/drawings	Yes/No	Yes	Yes	

9. HDPE PN4 PIPE (FOR OPEN TRENCH)

	DESCRIPTION	UNIT	NEA REQ		DATA to be Filled
			160mm dia	125mm dia	
1	Manufacturer and Country of Origin				
2	Applicable standard				
3	Type		HDPE PN4	HDPE PN4	
4	PE grade				
5	diameter of the pipe	mm			
6	Wall Thickness	mm			
7	Weight	Kg/mtr			
8	Technical Literature submitted	Yes/No	Yes	Yes	
9	Type test certificate submitted	Yes/No	Yes	Yes	
10	Technical literature/drawings	Yes/No	Yes	Yes	

10. 11KV SF6 EXTENSIBLE RMU

No.	Description	NEA Requirement	Offered Data
1	SWITCHGEAR ASSEMBLY		
1.1	Name of Manufacturer		
1.2	Country or Origin		
1.3	Year of Manufacturing Experience	10 Years	
1.4	Make	Manufacturer to give details	
1.5	Type	Outdoor	
1.6	Reference Standard	IEC 56, IEC129, IEC298, IEC694, IEC 265	
1.7	Voltage (Normal/Max.) kV	10kV/12 kV	
1.8	Phase (Nos.)	3 nos	
1.9	Frequency (HZ)	50 ± 3 Hz	
1.10	Short Circuit rating		
	a) Breaking Symmetrical (KA)	25 kA	
	b) Breaking Asymmetrical (KA)	25 kA	
	c) Short time for 3 Sec. (KA)	25 kA	
1.11	Insulation Level		
	a) Impulse withstand (KV peak)	75 kVp@1000mtr altitude	
	b) 1 Minute 50 Hz. Voltage withstand (KV rms)	28 kVrms@1000mtr altitude	
1.12	Metal Clad Construction	Yes	
1.13	Degree of protection for outer enclosure: Degree of protection for main tank:	IP 54 IP 67	
2	CONSTRUCTION		



2.1	Overall Dimensions	Mfg. to give details	
2.2	Overall Weight of RMU Unit	Mfg. to give details	
3	Bus bar	-	-
3.1	Make	Mfg. to give details	
3.2	Material & Grade	Copper	
3.3	Reference Standard	IEC 129	
3.4	Cross sectional area (mm ²)		
3.5	Continuous Current		
	a) Standard	630 A	
	b) At site conditions and within cubicle	630 A	
3.6	Maximum temperature rise over ambient (c)	55 °C (above ambient of 40 °C)	
3.7	Short time current for 3 Sec. (kA)	25	
3.8	Minimum clearance from bare bus bar	Mfg. to give details	
	a) Phase to phase (mm)		
	b) Phase to Earth (mm)		
3.11	Bus Bar support spacing (mm)		
3.12	Bus support insulators		
	a) Make		
	b) Type		
	c) Voltage Class (KV)		
	d) Minimum creepage distance (mm)		
	e) Cantilever strength Kg/mm ²		
3.13	SF6 gas pressure (filling pressure at 20 deg. C)	Mfg. to give details	
4.0	VCB CIRCUIT BREAKER		
4.1	Make	Mfg. to give details	
4.2	Type (Vacuum/ SF6)	Mfg. to give details	



4.3	Reference Standard	IEC 56	
4.4	Rated Voltage	11 kV	
4.5	Rated Frequency	50 Hz	
4.6	No. Of Poles	3	
4.7	Rated Current		
	a) Normal (Standard) Amps	630A	
	b) Rated (Site) Amps	630A	
4.8	Maximum temperatures rise over ambient.(deg. C)	55 °C (above ambient of 40 °C)	
4.9	Rated operating Duty	O- 0.3Sec- CO-3min- CO	
4.10	a) Short time current for 1 Sec.(KA rms)		
	b) Short time current for 3 Sec.(KA rms)		
4.11	Transient Recovery Voltage		
	a) Rate of rise (KV/ms)	0.34 KV/micro sec (as per IEC)	
	b) Peak Voltage (KV)		
4.12	Opening time Maximum No load condition (ms)	40-60	
4.13	Opening and closing time under SF6 gas loss or vacuum loss condition (ms)	40-60	
4.14	At 100% Breaking capacity		
	a) Opening time – max (ms)	40-60	
	b) Arcing time – max (ms)	6-9	
	c) Total break time (ms)	40-60	
4.15	At 60% Breaking capacity		
	a) Opening time – max (ms)	40-60	
	b) Arcing time – max (ms)	6-9	
	c) Total break time (ms)	40-60	



4.16	Number of breaks per pole	Single	
4.17	No of breaker operations permissible without requiring inspection replacement of contacts and other main parts.		
	At 100% rated breaking current		
4.18	Type of contacts		
	a) Main	Copper chromium, Butt type	
	b) Arcing	Copper chromium	
4.19	Material of contacts		
	a) Main	Copper chromium	
	b) Arching	Copper chromium	
	c) Whether contacts silver plated	NA	
	d) Thickness of silver plating	NA	
4.20	Operating mechanism- closing		
	a) Type	Stored Energy	
	b) No of breaker operations stored	One Trip free	
	c) Trip free or fixed trip		
	d) Anti pumping features provided		
	e) Earthing for operating mechanism and metal parts furnished	Mfg. to give details	
	f) Earth terminal size and material	Mfg. to give details	
4.21	Operating mechanism- tripping		
	a) Type	Mfg. to give details	
	b) No of breaker operations stored	One	
	c) Trip free or fixed trip (V)	Trip free	
	d) Anti pumping features provided (%)	NA	
	e) Earthing for operating mechanism and metal parts furnished	Mfg. to give details	

	f) Earth terminal size and material		
4.22	Spring charging mechanism		
	a) Make		
	b) Type		
	c) Size		
	d) Rating		
4.23	Breaker suitable for capacity switching 4 operating duty 5Max. rating of capacitor bank that can be safely controlled		
4.24	Tripping coil		
	a) Voltage		
	b) Permissible voltage variation (%)		
	c) Tripping current at rated voltage		
	d) Power at rated voltage (W)		
	e) 2-Over current trip with TLF (5A) and 1-earth fault furnished as specified		
4.25	Breaker/Accessories such as control switch indication Lamps etc. furnished as specified :(please attach separate sheet giving details of all accessories, interlocks and safety shutters)		
	a) Mechanical safety Interlock	Yes	
	b) Automatic Safety Interlock	No	
	c) Operational Interlock	Yes	
	d) Emergency manual trip	Yes	
	e) Operation counter	Yes	
	f) Charge /discharge indicator	Yes	
	g) Manual spring charging facility	Yes	
4.26	Impact load foundation design (to include dead load plus impact value on opening at maximum interrupting rating) (Kg)	Mfg. to give details	
4.27	Electrical class	E2	
4.28	Mechanical class	M1	



5.0	Isolators		
5.1	Make	Mfg. to give details	
5.2	Type	Mfg. to give details	
5.3	Reference standard	IEC129	
5.4	Rated voltage (KV)	12	
5.5	Rated Frequency Hz	50	
5.6	No. Of poles (No)	3	
5.7	Rated current		
	Normal (Standard) Amps	630	
	Derated (site) Amp	630	
5.8	Maximum temperature rise over ambient Deg. C	55 °C (above ambient of 40 °C)	
5.9	Rated operation duty		
5.10	Rupturing Capacity at rated voltage MVA	Mfg. to give details	
5.11	Rated making current KA peak	Mfg. to give details	
5.12	Short time current		
	a) For 1 sec KA rms	20	
	b) For 3 sec KA rms	20	
5.13	Impulse voltage withstand on 1/50 full Wave	75@1000mtr altitude	
5.14	Maximum over voltage factor when switching off a) Loaded feeder cable	Mfg. to give details	
5.15	Operating SF6 Gas pressure		
5.16	No of isolator operation permissible without requiring inspection, replacement of contacts and other main parts At 100% rated current At 100% rated breaking current		
5.17	Isolator provided with the following Mechanical safety	Yes	



	Mechanical ON, OFF, CABLE EARTH indicators Operation counter Manual spring charging facility		
5.18	Impact load for foundation design (To include dead load plus impact Values on opening at maximum interrupting rating) Kg	Mfg. to give details	
6.0	CURRENT TRANSFORMER		
6.1	Make	Mfg. to give details	
6.2	Type & voltage level	Mfg. to give details	
6.3	Reference standard	IEC 298	
6.4	C.T. ratio as specified	100-50/1 A	
6.5	Rated frequency	50	
6.6	Short circuit withstand Short time current for 1 sec. kA rms Short time current for 3 sec. KA rms Dynamic current KA peak	Mfg. to give details	
6.7	Class of insulation	Mfg. to give details	
6.8	Temperature rises over ambient. Deg. C		
6.9	Basic insulation level		
6.10	For tripping CT RATIO Class of accuracy		
	Rated Burden VA		
	Knee Point Voltage V		
	Excitation Current at $V_k/2$ Amps		
	Rated Saturating Current Amps		
	Over Current Rating		
	Continuous % Over Load %		
7.0	Cable terminations		
7.1	Circuit Breaker		
	Type		
	Materials		



	Dimensions		
	Size		
	Height of Cable box from ground Level		
	Arrangement for supplying bus end cable box furnished for extensible ring main Unit	Mfg. to give details	
	Arrangement for mounting an extra cable box on each equipment furnished		
7.2	Isolator		
	Type		
	Materials		
	Dimensions		
	Size		
	Height of Cable box from ground Level		
	Arrangement for supplying bus end cable box furnished for extensible ring main Unit		
	Arrangement for mounting an extra cable box on each equipment furnished	Mfg. to give details	
8.0	Name Plate		
8.1	Material		
8.2	Thickness		
8.3	Size for		
	Breaker Cubicle		
	Instruments / Devices		
9.0	Painting		
9.1	Finish of Breaker		
	Inside		
	Outside		
9.2	Finish of Isolator		

	Inside		
	Outside		
10.0	Drawing / Data		
10.1	General arrangement for Panel Board	Mfg. to give details	
	Arrangement for mounting an extra cable box on each equipment furnished		

11. LT FEEDER PANEL WITH MULTI-FUNCTIONAL METER

No.	Parameter Name	NEA requirement	Offered Data
1.	Name or Trademark of Manufacturer.		
2.	Type of L.T. Pillar		
3.	Rated normal voltage		
4.	Material of construction of L. T. Pillar enclosure & doors		
5.	Thickness of M.S. sheet for enclosure		
6.	Thickness of sheet for doors		
7.	Color of the L. T. Pillar enclosure		
8.	Dimensions of cubicle without rain hood – Width x Depth x Height (in mm)		
9.	Dimensions of rain hood – Width x Depth x Height of centre lift (in mm)		
10.	Ingress Protection	IP-55	
11.	Type of locking arrangements		
12.	Details of painting		
13.	Dimensions and details of asbestos sheets		
14.	Bus Bar		
	(a) Size of bus bar		
	(b) Size of neutral bus bar		
	(c) Grade and specification of material of Bus bars		
	(d) Rated normal current of Bus bars		
	(e) Rated safe temperature of Bus bars		
15.	No. of incoming and type of incoming		
16.	No. of outgoing and types of outgoing		
17.	Multi-Functional Meter	-	-
	(a) Make & Type		



	(b) Rated Voltage		
	(c) Rated Current		
	(d) Rated Frequency (Hz)	50Hz	
	(e) Accuracy	0.5 S	
	(f) Communication Method	GPRS	
18.	GPRS modem	-	-
	(a) Rated Voltage	3 phase AC 77 to 470 V or 1 phase AC 230 V	
	(b) Power Supply Unit	Drawn from meter input	
	(c) Average Power Consumption under idle and during data transfer	Not more than 3.5 VA	
	(d) Withstand Capacity	6.0 kV	
	(e) Operating Frequency Bands	GSM 900/1800 MHz	
	(f) Applicable Standards	ETSI GSM Phase 2+ Standard	
	(g) Short Message Service (SMS)	Yes	
	(h) Internet Services	TCP, UDP, HTTP, FTP	
	(i) Communication Interface	R2S32 Serial Link	
	(j) Maximum baud rate	115,200 bauds	
	(k) RS232 Output Connector	9 pin female/ RJ11	
19	SIM Card	-	-
	(a) Operating Voltage of Interface	1.8V/3V	
	(b) Applicable Standard for ESD	IEC61000-4-2	

12. 11M STEEL TUBULAR POLE

No.	Description	Unit	NEA Requirement	To be filled by Bidder/ Manufacturer
1	Manufacturer			
	Country of Origin			
2	Years of Manufacturing Experience	Years	10	
3	Governing Standard for Tubing, Manufacturing and Testing			
4	Are the poles fully Galvanized?	Yes/No	Yes	
5	Governing Standard for Galvanization		ISO 1461 or IS:4736 or an equivalent international standard	
6	Number of Sections	Number	3	
7	Overall Length	M	11	
8	Pole Designation		410 SP-57	
9	Section Length			
9.1	Top (h1)	M	2.7	
9.2	Middle (h2)	M	2.7	
9.3	Bottom (h3)	M	5.6	
10	Outside Diameter			
10.1	Top (h1)	Mm	139.7	
10.2	Middle (h2)	Mm	165.1	
10.3	Bottom (h3)	Mm	193.7	
11	Thickness			
11.1	Top (h1)	Mm	4.5	
11.2	Middle (h2)	Mm	4.85	
11.3	Bottom (h3)	Mm	5.90	



12	Crippling Load	Kgf	552	
13	Approximate Weight (excluding the weight of galvanization, base plate and pole cap)	Kg	256	
14	Application of load from top of pole	M	0.6	
15	Planting Depth	M	1.8	
16	Delivery of equipment following award of contract and approval of drawing	Months		
17	ISO 9001 holder (including design)	Yes/No	Yes	
17.1	Submission of ISO 9001 certificate	Yes/No	Yes	
18	Submission of Type test certificate	Yes/No	Yes	
18.1	Submitted for the required ratings	Yes/No		
18.2	Type test certified by			
19	Submission of User's certificate	Yes/No	Yes	
20	Experience of exporting to third country	Yes/No	Yes	
21	Outline Drawings and associated GA attached	Yes/No	Yes	

13. 9M STEEL TUBULAR POLE

No.	Description	Unit	NEA Requirement	To be filled by Bidder
1	Manufacturer			
	Country of Origin			
2	Years of Manufacturing Experience	Years	10	
3	Governing Standard for Tubing, Manufacturing and Testing			
4	Full Galvanization	Yes/No	Yes	
5	Governing Standard for Galvanization		EN ISO 1461 or IS:4736 or an equivalent international standard	
6	Number of Sections	Number	3	
7	Overall Length	M	9	
8	Pole Designation		410 SP-33	
9	Section Length	-	-	-
	a) Top (h1)	M	2.0	
	b) Middle (h2)	M	2.0	
	c) Bottom (h3)	M	5.0	
10	Outside Diameter	-	-	-
	a) Top (h1)	Mm	114.3	
	b) Middle (h2)	Mm	139.7	
	c) Bottom (h3)	Mm	165.1	
11	Thickness	-	-	-
	a) Top (h1)	Mm	3.65	
	b) Middle (h2)	Mm	4.50	
	c) Bottom (h3)	Mm	5.4	
12	Crippling Load	Kgf	435	



13	Approximate Weight (excluding the weight of galvanization, base plate and pole cap)	Kg	164	
14	Application of load from top of pole	M	0.3	
15	Planting Depth	M	1.5	
16	Delivery of equipment following award of contract and approval of drawing	Months		
17	ISO 9001 holder (including design)	Yes/No	Yes	
17.1	Submission of ISO 9001 certificate	Yes/No	Yes	
18	Submission of Type test certificate	Yes/No	Yes	
18.1	Submitted for the required ratings	Yes/No		
18.2	Type test certified by			
19	Submission of User's certificate	Yes/No	Yes	
20	Experience of exporting to third country	Yes/No	Yes	
21	Outline Drawings and associated GA attached	Yes/No	Yes	

14. GANG OPERATED SWITCH

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Manufacturer			
2	Country of Origin			
3	Model No.			
4	Year of manufacturing experience	Years		
5	Applicable Standards		IEC	
6	Type		Outdoor, Gapless, Zinc Oxide	
7	Rated Voltage	kV	12	
8	Rated Frequency	Hz	50	
9	Current Carrying Capacity	A		
10	Rated short time current	kA		
11	Rated peak withstand current	kA		
12	Rated line-charging breaking current	A		
13	Rated Cable charging breaking Capacity	A		
14	Number of Post Per Phase	Nos.		
15	Minimum Creepage Distance	mm		
16	Phase to Phase Clearance	mm	600	
17	Phase to Earth Clearance	mm		
18	Minimum distance between post insulator	mm	550	
19	Number of Poles	Nos.	3	
20	Number of Position	Nos.	2	
21	One Minute Power Frequency withstand Voltage (Dry and Wet)	kV		
22	Number of Nuts and Bolts for Current Carrying Connector	Nos		
23	Maximum Current Density	A/mm	1.6	



24	Minimum Cross Section for Current Carrying fixed contact	Sq.mm		
25	Length of post insulator arm	mm		
26	Size of Post Insulator arm	mm		
27	Operating Pipe outer Dia.	mm	32	
28	Operating Pipe inner Dia.	mm	25	
29	Length of Operating Pipe (minimum)	m	4	
30	Length of male contact on each side	mm		
31	Thickness of male contact	mm		
32	Width of male contact	mm		
33	Angle between male contact	Deg.	120 to 150	
34	Length of female contact	mm		
35	Thickness of female contact	mm		
36	Width of female contact	mm		

15. LIGHTNING ARRESTOR

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Manufacturer			
2	Country of Origin			
3	Model No.			
4	Year of manufacturing experience	Years		
5	Applicable Standards		IEC	
6	Type		Outdoor, Gapless, Zinc Oxide	
7	Voltage rating of LA	kV	9	
8	Nominal Discharge Current	kA	10	
9	Surge counter with insulating base furnished	Yes/No	NA	
10	Minimum power frequency spark over voltage	kV		
11	Maximum 1/50 impulse spark over voltage	kV		
12	Maximum front wave spark over voltage	kV		
13	Maximum switch surge spark over voltage	kV		
14	Number of section per pole			
15	Insulation level	kV		
15.1	Impulse withstand voltage (peak)	kV	75 @ 1000m altitude	
15.2	Power frequency withstand voltage (1min rms)	kV	28 @ 1000m altitude	
16	Creepage distance	mm	360	
17	Earth terminal and accessories provided	Yes/No	Yes	
18	Surge counter	Yes/No	NA	
19	ISO 9001 holder	Yes/No	Yes	
20	ISO 9001 certificate submitted	Yes/No	Yes	
21	Type test certificate submitted	Yes/No	Yes	



16. POLE CLAMPS

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Manufacturer			
2	Country of Origin			
3	Model No.			
4	Steel Classification			
	Governing Standard for galvanization			
5	Drawing of Pole Clamp furnished			



17. EARTH RODS AND CLAMPS

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Name of Manufacturer			
2	Country of Origin			
3	Model No.			
4	Material Description furnished?	Yes/No	Yes	
5	Governing Standard for galvanization			
6	Governing Standard for manufacturing and testing			
7	Applicable Standards			
8	Catalogue/Dimension drawings attached for all items?	Yes/No	Yes	
9	Dimensions (Ground Rod)			
	Length	mm		
	Diameter	Mm		
10	Catalogue number			
	Rod			
	Clamp			

18. GROUNDING CONDUCTOR

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Manufacturer and Country of Origin Model No.			
2	Governing Standard for manufacturing and testing			
3	Governing Standard for galvanization			
4	Standards attached?	Yes/No	Yes	
5	Cross Section	sq. mm		
6	Short time fusing 30 cycles	Amps		
7	Weight (Approx)	kg/km		
8	Length	mm		
9	Resistance at 20 deg C (Approx)	ohms/km		

19. GALVANIZED STEEL NUTS AND BOLTS

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Manufacturer			
2	Country of Origin			
3	Model No.			
4	Material Description furnished?	Yes/No	Yes	
5	Governing Standard for galvanization			
6	Governing Standard for manufacturing and testing			
7	Standards attached?	Yes/No	Yes	
8	Catalogue/Dimension drawings attached for all items?	Yes/No	Yes	

20. HIGH VOLTAGE WARNING/DANGER PLATE

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Manufacturer			
2	Country of Origin			
3	Model No.			
4	Applicable Standard			
5	Type of Material			
6	Size			
7	Submission of Technical literature/Drawing	Yes/No	Yes	

21. RTU (REMOTE TERMINAL UNIT)

No.	Description	NEA Requirement	To be filled by Bidder
1	Manufacturer		
	a) Name of manufacturer		
	b) Type		
	c) Years of Manufacturing	10 Years	
2	Cabinet		
2.1	Dimensions of cabinets (packs) completely equipped and wired		
	a) Height (mm)	Less than 2100 mm	
	b) Width (mm)		
	c) Depth (mm)		
	d) Weight (kg)		
2.2	Maintainability of cabinet		
	a) No preventive maintenance and inspections.	Yes/No	
	b) If required. No medium or high voltage circuit be de-energized.	Yes	
2.3	Corrosion Protection		
	a) The surface shall be cleaned to bare material by mechanical or chemical means.	Yes	
	b) One or more phosphatizing or priming coats of paint shall be applied to the bare surface using a zinc-based or lead-based primer.	Yes	
	c) A finish coat with high scratch resistance or epoxy powder finish paint shall be applied over the primer.		
	d) The coat thickness shall be no less than-as follows:		
	- Primer layer: Approx. 50 µm		
	- Intermediate layer (if necessary): Approx. 70 µm.		
	- Top coat (finish layer): Approx. 60 µm.		



	e) Finish-coat Color	RAL 7032 shade	
2.4	Ingress Protection	IP41	
2.5	Rodent Protection	Yes	
2.6	Galvanizing		
2.7	Marking		
3	Main Module		
	a) Manufacturer		
	b) Model/Type		
	c) Firmware version year		
	d) RTOS maker, name, version		
3.1	Central Processing Module (CPM)		
	a) The processor shall provide diagnostic information in the message structure that the DMS shall monitor. A flag shall be set if the RTUs performs a restart for any reason including power failure.	Yes	
	b) The programming language for RTU user applications shall comply with IEC 61131-3.	Yes	
	c) The CPM (Central Processing Module) shall be programmable in a high-level language like C. The Authority shall be able to program the RTU, manage the RTU database, upload/download parameters and configuration setting from the FRTU test set	Yes	
4	Power Supply		
	a) Power supply voltage	DC 48V	
	b) Power consumption	Not more than 100W	
5	Immunity to Electrical Stress and Disturbance		
	a) Minimum Insulation of Equipment		
5.1	Type test		
	a) Testing institutions Name		
	b) Exposed Equipment		
	c) Rated Insulation Voltage (IEC 60255-5, Table	500 V	



	I)		
	d) Dielectric Test Voltage (IEC 60255-5, Table I(Claude 6))	2 kV rms	
	e) Insulation Resistance Test: Required (IEC 60255-5, Clause 7)	Yes	
	f) Impulse Voltage Test (IEC 60255-5, Clause 8)	5 kV 1.2/50 μ s 0.5 J	
5.2	Controlled Exposure Equipment		
	a) Rated Insulation Voltage (IEC 60255-5, Table I)	60 V	
	b) Dielectric Test Voltage (IEC 60255-5, Table I(Claude 6))	1 kV rms	
	c) Insulation Resistance Test : Required (IEC 60255-5, Clause 7)	Yes	
	d) Impulse Voltage Test (IEC 60255-5, Clause 8)	5 kV 1.2/50 μ s 0.5 J	
5.3	Immunity from EMI, Radiated Disturbance, and Electrostatic Discharge		
	a) High Voltage Impulse (IEC 60060-1)	5 kV 0.5 J	
	b) Electrical Disturbances (1 MHz Burst) (IEC 60255-22-1, class 3)		
	c) CM (Common Mode)	2.5 kV	
	d) DM (Differential Mode)	1 kV	
5.4	Electrostatic Discharge Immunity:		
	a) Air (IEC 61000-4-2, Level 3)	8 kV	
	b) Direct 61000-4-2, Level 3)	6 kV	
	c) Radiated Immunity:		
	- 80 MHz - 1 GHz (IEC 61000-4-3, Level 3) or		
	- 27-500 MHz (IEC 60255-22-3, Class 3) or		
	- 50 kHz - 1 GHz (IEC 61000-4-3, Class 3) or		
	- 10 V/m 2 W at 0.6 m (ENV 50204 (GSM), Level 3)		
5.5	Fast Transient/Burst Immunity:		
	a) (IEC 61000-4-4, Level 4) or		



	- 4 kV On power supply port		
	- 2 kV On I/O Signal data and control		
	b) 4 kV (IEC 60255-22-4, Class 4) or		
	- 4-5 kV (ANSI/IEEE C37.90.1)		
	c) Surge Immunity (IEC 61000-4-5, Level 4)	2 kV/4 kV	
	d) Conducted Immunity (IEC 61000-4-6, Level 3)	10 V	
	e) Power Frequency Magnetic Field Immunity (IEC 61000-4-8, Level 3)	10 A/m	
	f) Pulse Magnetic Field Immunity (IEC 61000-4-9, Level 5)	100 A/m	
	g) Damped Oscillatory Magnetic Field Immunity (IEC 61000-4-10, Level 4)	30 A/m	
	h) Oscillatory Transient Immunity:		
	i) Ring Wave (IEC 61000-4-12, Level 3)	2 kV	
	j) Damped Oscillatory (IEC 61000-4-12, Level 3)	2 kV	
6	Safe Design		
6.1	Fail Safe Design Basic		
	a) Safe Default Operation	Yes	
6.2	Redundancy:		
	a) CPU	Yes	
	b) power supplies	Yes	
	c) communication interfaces	Yes	
6.3	Watchdog Timer:	Yes	
	a) Communication Monitoring and Timeout:	Yes	
	b) Data Protection and Backup:	Yes	
	c) Alarms and Notifications:	Yes	
	d) Fail-Open/Fail-Close Design:	Yes	
	e) Fail safe design Detail	Yes	
	f) The probability of undetected bit errors is no greater than		



	g) for data	10^{-10}	
	h) for control	10^{-14}	
6.4	Control output logic criteria		
	a) No false output shall result from a single point of failure in any Card	Yes	
	b) No false output shall result during power up or power down of the RTUs.	Yes	
	c) No false output shall result from inadvertently inserting a circuit card into a wrong slot within the FRTUs.	Yes	
7	Availability of diagnostic information		
7.1	Hardware Monitoring		
	a) Monitors CPU status		
	b) Memory usage		
	c) Power conditions		
	d) I/O modules overload or disconnection		
7.2	Communication Diagnostics		
	a) Tracks communication health with other devices		
	b) SCADA/DMS system in DCC		
	c) SAS		
	d) RMU/FRTU		
	e) Packet errors and timeouts.		
7.3	Signal Monitoring		
	a) Monitors abnormalities of digital and analog input/output signals		
7.4	Self-Diagnostics		
	a) watchdog timers		
	b) System logs, to automatically detect and recover from system hang-ups or malfunctions.		
	c) Environmental Monitoring		



	d) Monitors temperature and humidity		
	e) Firmware Diagnostics		
	f) Tracks firmware version and health,		
	g) detecting any errors or issues		
8	Maintainability		
8.1	I/O Module		
	a) Shall be replaceable without reprogramming, redefinition of configuration parameters, or rewiring	Yes	
	b) A control disable switch shall be provide within each I/O module	Yes	
8.2	Time and Date Facility		
	a) Local GPS receiver	Yes	
	b) Shall be synchronized using a GMT reference signal generated by the DMS in long format and properly accounting for relevant communication path delays	Yes	
	c) The resolution of the internal clock	1 ms or better	
	d) Real-time synchronization accuracy	1 ms	
	e) The internal clock must be re-synchronized using the DMS time and date reference signal when the unit is powered up	Yes	
9	Maintenance Tool (Portable Configuration and Maintenance Terminal, PCMT) (If required)		
9.1	Remote Configuration Tool or Configuration Software		
	a) Maintenance Tool Software		
	b) Engineering (Configuration) Tool Software		
	c) SCADA Configuration Utility Software		
9.2	Hardware		
	a) OS		
	b) Maker		
	c) Type/Model		



	d) CPU		
	e) Memory		
	f) Storage		
10	Input and Output		
10.1	Functional Requirements		
	Onboard battery	Yes/No	
10.2	Input/Out Points		
	a) Number of DI point		
	b) Number of DO point		
	c) Number of AI point		
	d) A/D converters, a digital resolution	at least 32,767 counts (sign plus 15 data bits)	
	e) Number of AO point		
10.3	Status Inputs (DI)		
	a) input dry contact with power supplied from RTU	Yes	
	b) The debounce time period for each status input shall be individually user configurable.	Yes	
	c) Optical isolate	Yes	
	d) LED indicator or LCD with keypad	Yes	
	e) Wetting Voltage	24~60 VDC	
	f) Single Contact, Two-State Status (SC-2S)	Yes	
	g) Double Contacts, Two-State Status (DC-2S)	Yes	
	h) Pulse Accumulators	Yes	
10.4	Control Outputs (DO)		
	a) Dry Contact	Yes	
	b) On/Off Device Control	Yes	
	c) Momentary control outputs	Yes	
	d) Pulse duration (adjustable)	0.1 to 25 s	



	e) Increment (pulse duration)	0.1 s	
	f) Command receipt timer (adjustable)	up to 20 s or longer	
	g) Control output contacts Voltage	24~130 VDC	
	h) Control output contacts operations		
	i) Control output relay driving load	6 A at primary control voltage	
	j) Select-Before-Operate (SBO)	Yes	
10.5	Configurable Serial Ports		
	a) Serial RS-232 ports	Yes	
	b) Serial RS-485 ports	Yes	
	c) for data communication with the DMS (1200-19200 bps)	1	
	d) for local diagnostic and test purposes (1200-19200 bps)	1	
	e) Protocol	MODBUS RTU	
11	Communication port		
11.1	Ethernet (IP) Communications		
	a) Master Station via SDH/MPLS		
	- Protocol:60870-5-104	Yes	
	- Port: Optical Ether Net	Yes	
	b) SAS via GW(Gateway)		
	- Protocol:60870-5-104	Yes	
	- Port: Optical Ether Net	Yes	
	c) Maintenance PC (PCMT)		
	- Protocol:	Yes	
	- Port: Ether Net	Yes	
	d) Local SCADA (if required)		
	- Protocol:	Yes	
	- Port: Optical Ether Net	Yes	



12	Data Processing		
12.1	Sequence of Events		
	a) Assignment of any status input point to SOE point	Yes	
	b) SOE resolution time of change	±1ms or better	
	c) SOE buffer sizing	At least 5,000 events	
	d) Reporting SOE events	Yes	
12.2	Scan Group		
	a) Number of Scan Group	At least 16 group	
13	Test		
13.1	RTU Testing		
	a) Test Plans and Test Procedures	Yes	
	b) Test Report	Yes	
	c) Factory Inspections and Test	Yes	
	d) Type Testing	Yes	
	e) The RTUs as a class, shall have passed type tests in accordance with IEC 60255-3, IEC 60255-5, IEC 60255-6, IEC 61000-4-2, and IEC 61000-4-3	Yes	
	f) Dielectric tests	Yes	
	g) Impulse voltage withstand tests	Yes	
	h) High frequency disturbance tests	Yes	
	i) Thermal requirement tests	Yes	
	j) Mechanical requirement tests	Yes	
	k) Contact performance tests	Yes	
	l) Electromagnetic radiation susceptibility tests	Yes	
	m) Electrostatic discharge susceptibility tests	Yes	
13.2	Factory Acceptance Test (FAT)		
	a) Full Functional Test	Yes	
	b) Factory Routine Test	Yes	



	c) Test Procedure	Yes	
	d) Factory Acceptance Test (FAT) Procedure including test circuit diagrams and Test Results Report Format	Yes	
13.3	Site Acceptance Test (SAT)	Yes	
	a) Site Acceptance Test (SAT) Procedure including test circuit diagrams and Test Results Report Format	Yes	
	b) Switchgear operation Test	Yes	
	c) End-to-End Test	Yes	
13.4	Test Equipment list and Calibration Certificate	Yes	
14	Documentation		
	a) Documentation Plan	Yes	
	b) Manuals	Yes	
	c) Installation Manual		
	d) User Manual		
	e) Configuration Manual		
	f) Maintenance Manual		
	g) Troubleshooting Manual		
	h) Technical Specifications Manual		
	i) Software Update Guide		
	j) Drawings	Yes	

22. FRTU (FEEDER REMOTE TERMINAL UNIT)

Item	Details	NEA Requirement	To be filled by Bidder
1	FRTU module		
	a) Manufacturer		
	b) Model		
	c) Firmware version year		
	d) Years of Manufacturing	10 Years	
2	Common Specifications		
2.1	Service Condition		
	a) Operation at elevations	up to 1,500 meters above sea level.	
2.2	Outdoor Devices		
2.2.1	Type test		
	a) Submission of Certified copy of type test certificates and test report	Yes	
	b) Temperature (per IEC 60068-2-1, 2 and 3)	-10°C to +60°C	
	c) Temperature Gradient (per IEC 60068-2-14)	up to 30°C	
	d) Relative Humidity (per IEC 60068-2-30)	up to 95% at 40°C	
	e) Cyclic Damp Heat (per IEC 60068-2-30)	40°C to 25°C at 95% Relative Humidity	
	f) Absolute Humidity (per IEC 60068-2-30)	up to 29 g/m3	
	g) Vibration (sinusoidal) (per IEC 60068-2-6)	2 g acceleration, 9 to 350 Hz	
	h) Shock test (per IEC 60068-2-27)	15 g 11 ms	
	i) For pole-mounted device	up to 10 degrees	
2.3	Fail Safe Design		
	a) The probability of undetected bit errors is no greater than		
	- for data	10 ⁻¹⁰	



	- for control	10 ⁻¹⁴	
2.4	Control output logic criteria		
	a) No false output shall result from a single point of failure in any Card	Yes	
	b) No false output shall result during power up or power down of the FRTUs.	Yes	
	c) No false output shall result from inadvertently inserting a circuit card into a wrong slot within the FRTUs.	Yes	
2.5	Maintainability		
	a) No preventive maintenance and inspections.	Yes/No	
	b) If required. No medium or high voltage circuit be de-energized.	Yes	
2.6	Ingress Protection	IP20, IP40 for front	
2.7	Marking		
2.8	Immunity to Electrical Stress and Disturbance	-	-
2.8.1	Minimum Insulation of Equipment	-	-
	Type test	-	-
	a) Exposed Equipment:	-	
	- Rated Insulation Voltage (IEC 60255-5, Table I)	500 V	
	- Dielectric Test Voltage (IEC 60255-5, Table I(Clause 6))	2 kVrms	
	- Insulation Resistance Test: Required (IEC 60255-5, Clause 7)	Yes	
	- Impulse Voltage Test (IEC 60255-5, Clause 8)	5 kV 1.2/50 us 0.5 J	
	b) Controlled Exposure Equipment:	-	-
	- Rated Insulation Voltage (IEC 60255-5, Table I)	60 V	
	- Dielectric Test Voltage (IEC 60255-5, Table I(Clause 6))	1 kVrms	
	- Insulation Resistance Test: Required	Yes	



	(IEC 60255-5, Clause 7)		
	- Impulse Voltage Test (IEC 60255-5, Clause 8)	5 kV 1.2/50 μ s 0.5 J	
2.8.2	Immunity from EMI, Radiated Disturbance, and Electrostatic Discharge		
	a) High Voltage Impulse (IEC 60060-1)	5 kV 0.5 J	
	b) Electrical Disturbances (1 MHz Burst) (IEC 60255-22-1, class 3)		
	c) CM (Common Mode)	2.5 kV	
	d) DM (Differential Mode)	1 kV	
2.8.3	Electrostatic Discharge Immunity		
	a) Air (IEC 61000-4-2, Level 3)	8 kV	
	b) Direct 61000-4-2, Level 3)	6 kV	
	c) Radiated Immunity:	-	-
	d) 80 MHz - 1 GHz (IEC 61000-4-3, Level 3) or		
	e) 27-500 MHz (IEC 60255-22-3, Class 3) or		
	f) 50 kHz - 1 GHz (IEC 61000-4-3, Class 3) or		
	g) 10 V/m 2 W at 0.6 m (ENV 50204 (GSM), Level 3)		
2.8.4	Fast Transient/Burst Immunity:		
	a) (IEC 61000-4-4, Level 4) or		
	b) 4 kV On power supply port		
	c) 2 kV On I/O Signal data and control		
	d) 4 kV (IEC 60255-22-4, Class 4) or		
	e) 4-5 kV (ANSI/IEEE C37.90.1)		
	f) Surge Immunity (IEC 61000-4-5, Level 4)	2 kV/4 kV	
	g) Conducted Immunity (IEC 61000-4-6, Level 3)	10 V	
	h) Power Frequency Magnetic Field Immunity (IEC 61000-4-8, Level 3)	10 A/m	
	i) Pulse Magnetic Field Immunity (IEC 61000-	100 A/m	



	4-9, Level 5)		
	j) Damped Oscillatory Magnetic Field Immunity (IEC 61000-4-10, Level 4)	30 A/m	
	k) Oscillatory Transient Immunity:		
	l) Ring Wave (IEC 61000-4-12, Level 3)	2 kV	
	m) Damped Oscillatory (IEC 61000-4-12, Level 3)	2 kV	
3	Functional Requirements		
	a) Onboard battery	No	
3.1	Input/Out Points		
	a) Number of DI point		
	b) Number of DO point		
	c) Number of AI point		
	d) A/D converters, a digital resolution	at least 16 bits plus sign	
	e) Number of AO point		
	f) Communication port:	-	-
	- Number of RS232 port		
	- Number of RS485 port		
	- Number of Ethernet Port		
	- Number of USB Port		
3.1.2	Status Inputs	-	-
	a) The debounce time period for each status input shall be individually user configurable.	Yes	
	b) Optical isolate	Yes	
	c) LED indicator or LCD with keypad	Yes	
	d) Wetting Voltage	24 VDC	
	e) Accommodated:	-	-
	- Single Contact, Two-State Status (SC-2S)	Yes	
	- Double Contacts, Two-State Status (DC-	Yes	



	2S)		
	- Pulse Accumulators	Yes	
3.1.3	Control Outputs	-	-
	a) On/Off Device Control	Yes	
	b) Momentary control outputs	Yes	
	c) Pulse duration (adjustable)	0.1 to 25 s	
	d) Increment (pulse duration)	0.1 s	
	e) Command receipt timer (adjustable)	up to 20 s or longer	
	f) Control output contacts Voltage	24 VDC	
	g) Control output contacts operations	106	
	h) Control output relay driving load	6 A at primary control voltage	
	i) Select-Before-Operate (SBO)	Yes	
3.2	Input/Out Points Counts		
3.3	Sequence of Events:		
	a) Assignment of any status input point to SOE point	Yes	
	b) SOE resolution time of change	±1ms or better	
	c) SOE buffer sizing	At least 20,000 events	
3.4	Feeder Fault Current Detection		
	a) Detecting the passage of feeder fault current	Yes	
	b) Capability to download and upload fault current setpoints and fault duration time periods	Yes	
	c) Designed to prevent misoperation due to magnetizing-inrush current and other transient no-fault conditions	Yes	
	d) Involving up to 3 reclosures prior to lockout	Yes	
	e) Reporting SOE events	Yes	
	f) Buffer	at least 128 events	



3.5	Configurable Serial Ports		
	a) Serial RS-232 ports	Yes	
	b) Serial RS-485 ports	Yes	
	c) for data communication with the DMS (1200-19200 bps)	1	
	d) for local diagnostic and test purposes (1200-19200 bps)	1	
	e) Protocol	MODBUS RTU	
3.6	Master Station Communications		
	a) 60870-5-104	Yes	
4	FRTU Architecture		
4.1	Central Processing Module		
	a) The processor shall provide diagnostic information in the message structure that the DMS shall monitor. A flag shall be set if the FRTUs performs a restart for any reason including power failure.	Yes	
	b) Applied RTOS (Real Time Operation System)		
	c) CPM shall be programmable in a high-level language like C. The Authority shall be able to program the FRTU, manage the FRTU database, upload/download parameters and configuration setting from the FRTU test set	Yes	
	d) Watch dog timer	Yes	
4.2	I/O Module		
	a) Shall be replaceable without reprogramming, redefinition of configuration parameters, or rewiring	Yes	
	b) A control disable switch shall be provided within each I/O module	Yes	
4.3	Time and Date Facility		
	a) Shall be synchronized using a GMT reference signal generated by the DMS in long format and properly accounting for relevant communication path delays	Yes	



	b) The resolution of the internal clock	1 ms or better	
	c) Real-time synchronization accuracy	1 ms	
	d) The internal clock must be re-synchronized using the DMS time and date reference signal when unit is power up	Yes	
4.4	Enclosures	Yes	
4.5	Power Supply	Yes	
	a) Voltage	24 VDC	
	b) Total burden (W)		
5	FRTU Test Set		
6	Software/Firmware		
6.1	General		
6.2	Diagnostic Software		
6.3	Programmable Logic Facility		
7	FRTU Testing		
7.1	Testing	Yes	
7.2	Test Plans and Test Procedures	Yes	
7.3	Test Report	Yes	
7.4	Factory Inspections and Test	Yes	
	a) Type Testing	Yes	
	b) The FRTUs as a class, shall have passed type tests in accordance with IEC 60255-3, IEC 60255-5, IEC 60255-6, IEC 61000-4-2, and IEC 61000-4-3	Yes	
	c) Dielectric tests	Yes	
	d) Impulse voltage withstand tests	Yes	
	e) High frequency disturbance tests	Yes	
	f) Thermal requirement tests	Yes	
	g) Mechanical requirement tests	Yes	
	h) Contact performance tests	Yes	
	i) Electromagnetic radiation susceptibility	Yes	



	tests		
	j) Electrostatic discharge susceptibility tests	Yes	
7.5	Factory Acceptance Test		
7.5.1	Full Functional Test	Yes	
7.5.2	Factory Routine Test	Yes	
7.5.3	Site Acceptance Test	Yes	
7.5.4	End-to-End Test	Yes	
7.6	Test Equipment	Yes	
8	Documentation Plan	Yes	
8.1	Instructor Manuals	Yes	
8.2	Drawings	Yes	

23. SDH/MPLS SWITCHABLE OPTICAL TERMINAL

No.	Description	NEA Requirement	To be filled by Bidder
1	Manufacturer		
	a) Name of manufacturer		
	b) Type		
	- Power supply voltage	To apply the contractor supply 48Vdc system	
	- Consumption (W)		
2	Installation and size		
	a) To be installed in RTU cabinet		
	b) 19 inch Rack mount type		
	- Size: W (width) x H (height) x D (depth)		
3	Function		
	a) Supported Protocols:		
	- SDH, MPLS, MPLS-TP (Transport Profile)	Ensures the equipment supports both SDH and MPLS protocols	
	b) IEC607870-5-104 Protocol handling		
	- TCP/IP over SDH	Yes	
	- Encapsulation (VC-12, VC-4)	Yes	
	c) Transmission Speed:		
	- Supported transmission speeds for both SDH and MPLS	STM-1, STM-4, STM-16, STM-64, 1Gbps, 10Gbps, 40Gbps, 100Gbps	
	d) Cross-Connect Function		
	- Digital Cross Connect (DXC), Ethernet Cross Connect	Cross-connect functionality between SDH and MPLS	
	- SDH Layer Cross-connect	(TDM multiplexing at VC-12, VC-4 level)	
	e) Protection Features		



	- MSP (Multiplex Section Protection), SNCP (Sub-Network Connection Protection), Fast Reroute	Protection features for both SDH and MPLS	
f)	Synchronization		
	- SSU (Synchronization Supply Unit), SyncE (Synchronous Ethernet)	Synchronization support for both SDH and MPLS networks	
g)	Label Switching Function		
	- Label Distribution Protocol (LDP), RSVP-TE	Label switching protocols for MPLS networks	
h)	VPN Support		
	- L2VPN, L3VPN, VPLS	VPN support within the MPLS network	
i)	Bandwidth Management		
	- Bandwidth Allocation, Traffic Engineering, Load Balancing	Bandwidth management, traffic engineering, and load balancing	
j)	Service Interfaces		
	- Ethernet over SDH (EoS), Ethernet over MPLS (EoMPLS), TDM over MPLS	Support for Ethernet and TDM services over both SDH and MPLS	
k)	Management Functions		
	- SNMP, CLI, Web Interface, Network Management System (NMS)	Management and monitoring support for both SDH and MPLS	
l)	Security Features		
	- Access Control, Encryption, Authentication	Security features for both SDH and MPLS	
m)	Applicable Standards		
	- ITU-T G.707, G.783, G.803, RFC 3031, RFC 4364	Compliance with standards for both SDH and MPLS	
n)	Scalability Architecture, Multi-Protocol Support		
	- Scalability to accommodate future upgrades and protocol transitions from		



	SDH to MPLS		
	o) Diagnostics and Alarms		
	- Remote Diagnostics, Alarm Notification, Path Trace, Ping, Traceroute	Diagnostic and alarm notification functions, path analysis capabilities	
	p) Redundancy		
	- Redundant Power Supply, Redundant Processor, Fast	Ensuring redundancy for both SDH and MPLS	
	- Reroute (MPLS), Path Protection (SDH)		
	q) Power Requirements		
	- DC 48V, AC 230V	Required power type and voltage	
	r) Environmental Tolerance		
	- Temperature, Humidity, Vibration, Shock	Tolerance to environmental conditions (temperature, humidity, vibration, shock)	
	s) Throughput		
	- Maximum Throughput	Maximum throughput (data transfer capacity)	
	t) Software Upgrades		
	- In-Service Software Upgrades (ISSU), Automated Patching	Software update functionality (ability to update without service interruption)	
	u) Installation and Maintenance		
	- Easy Installation, Low Maintenance Requirement	Easy installation and low maintenance requirements	

Here is a summary of the technical particulars and guarantees table for a GPRS modem, similar to the LoRa F8L10 model:

Technical Particulars and Guarantees for GPRS Modem

No.	Description	NEA Requirement	To be filled by Bidder
1	Modem Model	Equivalent to LoRa F 8L10	
2	Operating Frequency	GSM 900/1800 MHz	
3	Communication Protocol	TCP/IP, UDP, HTTP, FTP, SMS	
4	Supported Features	POTA (Program Over the Air), SMS Alerts, Auto-restart	
5	Interface	RS232, RS485, Ethernet (optional)	
6	Communication Speed	Up to 115,200 bps	
7	Data Collection	Meter data, instantaneous values, billing data, tamper data	
8	Meter Compatibility	Compatible with DLMS/COSEM and IEC 62056 meters	
9	GPRS Class	Class 10/12	
10	Power Supply	48V DC / 110V DC / 230V AC (single/three-phase)	
11	Power Consumption	Max 3.5 VA	
12	Operating Temperature	-10°C to +55°C	
13	Humidity	Up to 95% RH (non-condensing)	
14	Enclosure	Polycarbonate, IP55-rated	
15	EMI/EMC Compliance	IEC 61000-4-2, 61000-4-4, 61000-4-5	
16	SIM Card Compatibility	1.8V/3V	
17	Antenna Specification	SMA connector, built-in antenna (-6dbi), external antenna option (14dbi)	
18	Firmware Update	Over the Air (OTA)	
19	Data Transmission Interval	Configurable (15 min, 30 min, 1 hour)	
20	Real-Time Alerts	Power, network, communication error alerts	
21	Software Tools	Configuration, remote management, firmware update tools	
22	Remote Management	Remote reset, configuration	



		change, data collection	
23	Security	AES 128/256-bit encryption, VPN support	
24	Test Reports	Required EMI/EMC test reports compliant with IEC 61000-4	



24. UNDERGROUND FIBER OPTIC CABLE (UGFO) – 24 FIBERS

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Name of Manufacturer			
2	Country of Origin			
3	Year of Manufacturing Experience	Years	10	
4	No. of Fibres: Dual Window Single-Mode:	No.	24	
5	No. of loose Tubes	No.	6	
6	No. of Fibre / tube	No.	4	
7	Cable Diameter	Mm	13.2	
8	Nominal cable weight	Kg/km	140	
9	Inner sheath thickness	Mm	1.2	
10	Outer sheath thickness	Mm	1.6	
11	Expected Cable Life:	Year	25 Year	
12	Whether the offered design(s) of UGFO conforms to the technical specification requirements	-	Yes/No	

25. UNDERGROUND FIBER OPTIC CABLE (UGFO) – 96 FIBERS

No.	Description	Unit	NEA requirement	To be filled by Bidder
1	Name of Manufacturer			
2	Country of Origin			
3	Year of Manufacturing Experience	Years	10	
4	No. of Fibres: Dual Window Single-Mode:	No.	96	
5	No. of loose Tubes	No	8	
6	No. of Fibre / tube	No	12	
7	Cable Diameter	Mm	14.5	
8	Nominal cable weight	kg/km	175	
9	Inner sheath thickness	Mm	1.2	
10	Outer sheath thickness	Mm	1.6	
11	Expected Cable Life:	Year	25 Year	
12	Whether the offered design(s) of UGFO conforms to the technical specification requirements	-	Yes/No	

26. DUAL-WINDOW SINGLE MODE (DW-SM)

No.	Description	NEA Requirement	To be filled by Bidder
1.	Fiber manufacturer(s) / Type:		
2.	Attenuation Coefficient		
	- 1310 nm:	≤ 0.35 dB/km	
	- 1550 nm:	≤ 0.21 dB/km	
3.	Point discontinuity @ 1310nm:		
	- 1310 nm:	≤ 0.05 dB	
	- 1550 nm:	≤ 0.05 dB	
4.	Nominal Mode Field Diameter		
	- 1310 nm:	8.6 to 9.5 μm (± 0.6 μm)	
	- 1550 nm:	8.6 to 9.5 μm (± 0.6 μm)	
5.	Chromatic Dispersion Coefficient		
	- 1310 (1288-1339) nm:	3.5 ps/(nm x km)	
	- 1310 (1271-1360) nm:	5.3 ps/(nm x km)	
	- 1550 nm:	18 ps/(nm x km)	
6.	Zero dispersion wavelength:	1300 to 1324 nm	
7.	Cutoff wavelength:	≤ 1260 nm	
8.	Bend Performance:		
	- (37.5 mm radius, 100 turns) @1310 nm	≤ 0.05 dB	
	- (30 mm radius, 100 turn) @1550 nm	≤ 0.05 dB	
	- (16mm radius, 1 turn) @ 1550nm	≤ 0.05 dB	
9.	Cladding Diameter (nominal $\pm$ deviation):	125.0 μm ± 1 μm	
10.	Polarisation mode dispersion coefficient	≤ 0.2 ps/km ^{1/2}	
11.	Proof test level	≥ 0.69 Gpa	



PART 2C
EMPLOYER'S REQUIREMENTS FOR
DISTRIBUTION LINE WORK

APPENDIX – C2:
DRAWINGS FORMING PART OF SPECIFICATIONS



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APPENDIX – C2: DRAWINGS FORMING PART OF SPECIFICATIONS

Refer to ANNEX-3 in Volume of Annex



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