The Afghanistan Engineering Support Program assembled this deliverable. It is an approved, official USAID document. Budget information contained herein is for illustrative purposes. All policy, personal, financial, and procurement sensitive information has been removed. Additional information on the report can be obtained from Firouz Rooyani, Tetra Tech Sr. VP International Operations, (703) 387-2151.

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ENGINEERING SUPPORT PROGRAM

WO-LT-0063-Salang Tunnel Substation Technical Sections Report

Submitted: January 27, 2013

This publication was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech, Inc.

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January 27, 2013

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Re: WO-LT-0063 – Salang Tunnel Substation Technical Section – Report

[redacted]

Enclosed is the Salang Tunnel Substation Technical Section report.

I look forward to meeting with you at your convenience to discuss this report.

Respectfully,

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AFGHANISTAN ENGINEERING SUPPORT PROGRAM

WO-LT- 0063
Salang Tunnel Substation Technical Sections Report

January 27, 2013

Executive Summary

Approach

This report provides a technical scope of work for procurement of a 220kV transmission line (T/L) tap and associated electrical substation to be installed near the northern entrance of the Salang Tunnel. These facilities are to be developed as part of the initiative generally known as the Power Transmission Expansion and Connectivity (PTEC) program. This document has been prepared by Tetra Tech (TT) under the Afghanistan Engineering Support Program (AESP) with USAID, work order WO-LT-0063.

This report provides a technical scope of work with supporting engineering documents (drawings and specifications) that may be readily incorporated into a request for proposal (RFP) to procure transmission line design and construction services. Sufficient information is provided for a competent design build (DB) or engineer/procure/construct (EPC) firm to execute final design and construct the system.

Findings

__Consultation__

The project team consulted with Afghanistan energy sector organizations including Da Afghanistan Breshna Sherkat (DABS) and Ministry of Energy and Water (MEW) to ensure the work product would be compatible with the proposed DABS 'on-budget' procurement process supported by USAID. Consultation included meetings with DABS and USAID management, preliminary draft document reviews, and an abundance of email communications among interested parties to resolve minor technical issues and provide scope clarification.

__Specification Reviews__

Previously issued RFP packages used successfully by DABS in the past were provided to the project team as examples. The RFP examples were used in the development of this technical specification document as follows:

1. Design, Supply, and Installation for Kunduz – Taloqan 220kV Transmission Line Project Tender No. :DABS/OO1/ICB
2. RFP for Northeast Power System (NEPS) Electrical Transmission Projects, Afghanistan (US Army Corps of Engineers)
3. Asian Development Bank (ADB), Power Transmission and Distribution Project ADB Loan No. 2165-AFG(SF)/Grant 0004-AFG(SF); Supply, Delivery and Installation Contracts for Lots 1 & 2, Bidding Documents, June 2005

__Engineering Study__

Technical data has been obtained and adapted for use in the transmission line tap and substation technical specification document as follows:

Technical Data Type	***Source***
General Specifications	Kunduz – Taloqan 220kV T/L
Transmission Line Drawings and Specifications	Kunduz – Taloqan 220kV T/L
Substation Specifications	ADB Loan No. 2165
Substation Sizes, Plot Plans, Control Diagrams, One-Line Electrical Diagram	RFP for NEPS Electrical Transmission Projects

The subject transmission line system to be tapped is a 220kV system. Substation locations and transformer sizes (Salang – 1x4MVA) were identified through consultation with DABS.

The specified transmission line tap and substations will be part of the NEPS system.

Conclusion

This technical scope of work document provides sufficient technical information for a competent DB or EPC firm to perform final design and install the proposed T/L tap and construct the substation systems required to support the Salang Tunnel operations as well as nearby minor electricity consumers. Data was assembled from consultation with USAID, DABS and MEW, as well as from specification details extracted from client-provided example tender documents. To the extent practicable, the technical scope of work has been structured to follow the DABS example RFP format.

ISLAMIC REPUBLIC OF AFGHANISTAN
DA AFGHANISTAN BRESHNA SHERKAT (DABS)

INTERNATIONAL COMPETITIVE BIDDING

For

DESIGN, SUPPLY AND INSTALLATION of Salang Tunnel Transmission Line Tap and 220/20kV Substation Project

TENDER No. :

AFG No.:

USAID GRANT AGREEMENT NUMBER:

VOLUME 2 OF 3

January 2013

Table of Contents - Summary Description

VOLUME - 1

PART I BIDDING PROCEDURES

Section 1 - Instructions to Bidders (ITB)

This section specifies the procedures to be followed by Bidders in the preparation and submission of their Bids. Information is also provided on the submission, opening, and evaluation of bids and on the award of contract.

Section 2 - Bid Data Sheet (BDS)

This section consists of provisions that are specific to each procurement and supplement the information or requirements included in Section 1 - Instructions to Bidders.

Section 3 - Evaluation and Qualification Criteria (EQC)

This Section contains all the criteria that the Employer shall use to evaluate bids and qualify Bidders. In accordance with ITB 36 and ITB 38, no other methods, criteria and factors shall be used. The Bidder shall provide all the information requested in the forms included in Section 4 (Bidding Forms).

Section 4 - Bidding Forms (BDF)

This Section contains the forms which are to be completed by the Bidder and submitted as part of his Bid.

Section 5 – DABS and Grantor Requirements

This section contains the clauses that are incorporated from the Prime Grant Agreement and are applicable to all contractors and subcontractors.

VOLUME - 2

PART II REQUIREMENTS

Section 6 - Employer's Requirements (ERQ)

This Section contains the Specification, Schedule of Supply, the Drawings, and supplementary information that describe the plant and services to be procured.

DRAWINGS AND ATTACHMENTS

Drawings
Typical Drawings for Insulators, Hardware and Accessories
Informative Earthquake Maps

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PART III CONDITIONS OF CONTRACT AND CONTRACT FORMS

Section 7 - General Conditions of Contract (GCC)

This Section contains the general clauses to be applied in all contracts. These Conditions are subject to the variations and additions set out in Section 8 (Special Conditions of Contract).

Section 8 - Special Conditions of Contract (SCC)

This Section supplements the General Conditions of Contract (GCC). Whenever there is a conflict, the provisions herein shall prevail over those in the GCC. The clause number of the SCC is the corresponding clause number of the GCC.

Section 9 - Contract Forms (COF)

This Section contains the Notification of Award, Letter of Acceptance, the Contract Agreement and Appendices to the Contract Agreement which, once completed, will form part of the Contract.

Preface

The Bidding Document for procurement of Design, Supply and Installation is based on the Standard Bidding document for Procurement Plan - Design, Supply and Install issued by DABS.

DABS has the structure and the provision of the Master Procurement Document “Procurement of Plant – Design, Supply and Install”, prepared by multilateral development banks and other public international financial institutions except where DABS – Specific considerations have required a change.

Acronyms and Definitions

ACSR	Aluminium Conductor Steel Reinforcement
AFRM	Afghanistan Residence Mission
ANSI	Amercan National Standard institute
AP	Angle Point
ASCE	American Society of Civil Engineers
Aspen DistriView	A computer analysis software see www.aspeninc.com
ASTM	American Society of Testing Materials
BDS	Bid Data Sheet
BOQ	Bill of Quantity
BS	British Standard
Cct-km	Circuit Kilometer (Double Circuit, 3Phase, Twin Conductor Per Phase)
COF	Contract Forms
CPA	Condtions of Particular Application
Cu.m, m^3	Cubic Meters
DA	Double Circuit Tower Type – A (Suspension)
DABS	Da Afghanistan Breshna Sherkat
DB	Double Circuit Tower Type – B (Tension)
DC	Double Circuit Tower Type – C (Tension)
DCPT	Dynamic Cone Penetration Test
DD	Double Circuit Tower Type – D (Tension)
DDM/DDE	Double Circuit Tower Type – DDM/DDE (Tension/Dead End)
DDP	Delivery Duty Paid
DDU	Deliver Duty Unpaid
deg	Degree
DIN	Deutsches Institute für Normung e.V.
DS	Direct selection
ELC	Eligible countries
Engineer	DABS Designated Technical or Contract Representative
Employer	DABS
EQC	Evaluation and Qualification criteria
EXW	Ex factory, ex works or ex warehouse
FC	Foreign Currency
FIDIC	Federation Internationale des Ingenieurs Conseils (International Federation of Consulting Engineers
FOB	Free on Board
g/m^2	Gram Per Meters Square
GCC	General Conditions of Contract
ICC	International Chamber of Commerce
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFB	Invition for Bids

ISO	International Standards Organization
ITB	Instruction to Bidders
kg	Kilogram
kg/cm^2	Kilogram Centimeter Square
kN	Kilo Newton
kV	Kilo Volt
l.m, m	Linear Meters, Meters
L.S	Lump Sum
LARP	Land Acquisition and Resettlement Plan
LC	Local Currency
m/sec	Meter per Second
MEW	Ministry of Energy and Water
MOSS	Minimum Operating Safety standards
N	Newton
No.	Number
NoC	Negotiation of Contract
N/mm^2	Newton per Milimeter Square
OPGW	Optical Fiber Ground Wire
Owner	DABS
Owners Engineer	DABS Appointed/Selected Technical Representative(s)
PCC	Plain Cement Concrete
PCU	Project Coordination Unit
PDF	Proposal Forms
PDS	Proposal Data Sheet
PISU	Programme Implementation Support Unit
PMG	Permanent Magnet Generator
PMO	Project Management Office
RCC	Reinforced Cement Concrete
RFP	Request for Proposal
RoW	Right of Way
SCADA	Supervisory Control and Data Acquisition
SCC	Special Conditions of Contract
SMEC	Snowy Mountains Engineering Corporation
SPT	Standard Penetration Test
sq.m, m^2	Square Meters
sq.mm, mm^2	Square Milimeter
TIF	Telephone Influence Factor
Ton	Metric Ton
UN	United Nation
UNMACA	United Nations Mine Action Center, Afghanistan
UXO	Unexploded Ordinance
VDE	Verband Der Electrotechnik Electronik Informationstechnik e.v

Section 6

Employer's Requirement

Contents

List of Tables

Appendices

1.0 Technical Specification

1.1 Project Description

1.1.1 Overview

The existing Northeast Power System (NEPS) is a 220kV transmission system that extends power from Uzbekistan and Tajikistan down the Salang Pass to Pul-e-Khumri in northern Afghanistan.

This contract will expand the 220kV high voltage power system in Northeastern Afghanistan in order to provide electricity to the Ministry of Public Works (MoPW) at their facilities that serve electrical loads at the Salang Tunnel. The objective of this project is to provide a cost effective, reliable system for the distribution of electric power to the Salang Tunnel.

1.1.2 Contract 1A: 220kV Transmission Line Tap (Lot No. 1)

Design, construct, test, and commission a fully functioning 220kV electrical transmission system tap to deliver power from the existing 220kV transmission line to the Salang Tunnel Substation.

Pricing shall include design of a complete simplex conductor 220kV single circuit transmission system and construction of a complete simplex conductor single circuit from the tap point to the Salang Tunnel Substation.

The Base Bid transmission system design and construction pricing shall include some individual unit prices as well as lump sum pricing and total price for Lot No. 1 as detailed in the Schedule of Supply associated with this specification.

Transmission system scope shall include design and installation of optical fiber cable for Supervisory Control and Data Acquisition (SCADA), telecommunication and trip signal. The Contractor shall coordinate termination and commissioning of the optical fiber communication system with the Employer’s Engineer.

The transmission line tap shall be designed and constructed per drawings Volume 2, Section 4.0; Drawing E-301, E-302, and E-303.

1.1.3 Contract 1B: Design and Construct One Substation (Lot No. 2)

Substation scope shall include demining, grading, fencing, structures and all substation buildings as well as design and installation of optical fiber cable for SCADA, telecommunication and trip signal, including ringed fiber optic cabling within the substations and all terminating and multiplexing equipment within the control rooms and at the termination to the transmission line overhead ground wire. Scope shall include coordination studies in electronic format using Aspen DistriView and printed format to Employer’s Engineer. Contractor shall provide and install relay settings for all protective equipment supplied under this specification.

The Contractor shall coordinate termination and commissioning of the optical fiber communication system through the Employer’s Engineer.

SCADA project scope shall include integration of all transmission system control points, trip signals, and system indication (breaker trip, switch position, etc.) via marshaling panels located at each substation constructed under this contract. Hardware and software shall be specified, configured, and tested to support remote control and indication of power flow through the transmission line from the National Load Control Center (NLCC). Work shall include any and all software programing changes and hardware additions necessary to have the NLCC see and operate the substation equipment.

Salang Tunnel Substation

Design and construct a complete Salang Tunnel Substation with one 220kV circuit to include one simple conductor circuit from the transmission line tap, and sufficient area for zero 220kV bay spaces for future expansion. The 220kV bays shall be designed to provide cost effective reliable grid connections.

Included shall be all of the equipment that would be necessary to permit the one 220kV simplex transmission line circuit to land and be energized by the Salang Tunnel Substation. The installation shall include all required breakers, switches, arrestors, metering equipment and other components necessary to have the one simplex circuit operable.

The substation shall also be designed and constructed with a 20kV yard, one 220/20kV transformer rated no less than 4MVA, a 20kV line bay, 20kV yard equipment, 20kV indoor switchgear, and line dead-end structures for connection to 20kV distribution lines.

Substation design and construction shall include all 220kV and 20kV bus and structures necessary to support future circuits indicated in the drawings.

The Salang Tunnel Substation shall be designed and constructed per drawings Volume 2, Section 4.0; Drawing E-401, E-402, E-403 and E-404.

1.1.4 Contract 1C: 20kV Feeder (Lot 3)

Provide and install Medium voltage (20kV) switchgear at the Ministry of Public Works (MoPW) site near the southern portal of the Salang Tunnel. A 20kV bulk power revenue meter for NEPS to bill MoPW will be included in the switchgear.

The design will include a 20kV sub-transmission feeder between the substation and the bulk power revenue metering switchgear.

The existing TPP sources (diesel generators) will remain unaltered and unable to synchronize with NEPS power. Their function will henceforth be for standby use. "Kirk-key" interlocks will be provided on each generator circuit breaker and the MV circuit breaker in the substation dedicated to MoPW loads to prevent parallel operation.

Engineer, procure and construct in accordance with DABS standards as detailed in Appendices A, B and C and through consultation with DABS.

1.1.5 220kV Transmission Line connection from tap to Salang Tunnel - General

The transmission line works covers the construction of approximately 2km of a 220kV single circuit transmission line from the 220kV tap to the 220kV substation at Salang Tunnel. Included in this scope is the construction of one 220/20kV substation at locations as shown in Table 2.1.1.

Table 1.1.1 Substation Locations and Capacities

Location	Bid Option	Voltage	Transformation Capacity	Substation Plan Volume 2, Section 4.0	Approximate Location	Approximate Elevation
Salang Tunnel	Base	220/20kV	1 x 4MVA	E-402	35.296˚ N 69.064˚ E	3,200m

The line route covers terrain including rocky and loose slope mountains. Elevations range from approximately 3,600m – 3,200m AMSL.

The alignment of new line shall be based on the detailed site survey to be carried out by the Contractor. Where there has been an existing line, the alignment of the new line shall generally be as per existing structures. However, no existing foundations, steel, or equipment shall be used.

The sites will normally be approached from the existing main and secondary roads. However, it is the responsibility of the Contractor to ensure the adequacy of the access roads, as well as tracks to tower sites.

All access roads will be considered as temporary construction roads, of which the Contractor is in charge, and no additional payment will be made for these roads, apart from the Lump Sum allowance the Contractor has in price schedules. All access roads shall be removed after the completion of construction and the land returned to the original condition.

The scope of work comprises the design, supply and erection of a substation, all required substation equipment (transformers, circuit breakers, switches, etc.), control facilities, steel lattice double circuit towers for the said project, as well as installation of conductors, optical fiber ground wire (OPGW) and ancillary works, to provide a reliable transmission system to the satisfaction of the Employer. The towers shall be self-supporting, hot dip galvanized lattice steel type, & designed to carry the simplex line conductors per phase, insulators, OPGW type shield wire, and all fittings to suit all loading conditions.

Reference diagrams of transmission line towers and substation plans are included in the drawings, Volume 2, Section 4.0.

The bid hereinafter referred to as “the Works” shall be performed on a Turnkey basis. The Contractor shall execute all temporary and permanent works, whether particularized in these Specifications or not, necessary for a timely and successful Taking-Over of the Works. The Taking-Over shall be within 18 months from the date of commencement of the Works plus 2 additional months for testing and commissioning for only the substation contractor performing Contract 1B.

This scope of work for the transmission system Design, Manufacture and Supply, Construction, Erection, Installation, Testing and Commissioning includes the following components:

A. Prepare detailed design and construction services for new substations and support facilities including specified civil works at Salang Tunnel (Contract 1B). Detailed designs shall conform to substation types and sizes detailed in Table 2.1.1 and conceptual design drawings in Volume 2, Section 6.0 of this specification.

B. Prepare final design deliverables including detailed substation, transmission line, and tower drawings, specifications, and supporting analyses. Prepare shop drawings as required. Submit for Employer and Engineer review. Incorporate comments and resubmit as described in Section 2.2.8.

C. Detailed survey including approved route alignment and profiling, right-of-way (RoW) identification and clearance, tower spotting, optimization of tower locations, soil resistivity measurements, and geological investigation works. The Engineer shall check the Contractor’s tower optimization work, using PLS-CADD and any differences shall be subject to the Engineer’s final decision.

D. Engineering, design, type test of materials, proto type tower testing, fabrication and supply of all types of transmission line towers including bolts, nuts, washers, hangers, D-shackles and all types of tower accessories such as phase plates, circuit plates, number plates, danger plates, air borne observation number plate anti-climbing devices, step bolts etc.

E. Supply of conductor, composite long rod insulators, OPGW, and compatible hardware fittings for conductors and accessories.

F. Transportation of all materials and plant to site, proper storage and plant preservation, including all services to be required at Customs (i.e., including unloading, loading, storing at site or Customs stores and other services). Design and classification of foundations for different soil conditions for different types of towers, excavation, backfilling and casting of concrete foundations for towers, as per approved drawings.

G. Erection of towers, tack welding of bolts and nuts including supply and application of zinc rich paint on scratched portions, tower grounding (earthing) and if required counterpoising, stringing of conductors and OPGW, fixing of insulator strings, vibration dampers, arcing horns, conductor spacers, air craft warning spheres along with all necessary line accessories. Tower designs and accessories shall conform to conceptual design drawings included in Volume 2, Section 6.0

H. Stringing and final tensioning of conductors and OPGW work shall extend from dead-end terminal towers to the substations' take-off structure (gantry) at Salang Tunnel. The Transmission contractor (Contract 1A) shall provide sufficient surplus conductors at the terminal towers, to facilitate connections to substation plant. Termination shall be performed by the Substation contractor (Contract 1B) once the dead-end terminal towers are installed so as to allow 2 additional months of testing and commissioning to proceed.

I. Provision and recommendation of spare parts as per the specification and price schedule for 5 years operation.

J. Commissioning and acceptance testing including provision of necessary testing equipment, instruments and devices.

K. On-the-job training of the personnel authorized by the Employer.

L. Strict implementation of Health, Safety, Environmental, and Social safeguards at site and as required as per the project specification and AIF guidelines.

M. Establishment and implementation of Land Acquisition and Resettlement Plan (LARP).

N. Supply of Emergency Restoration System Towers, including providing training and an operation manual, hardware and fittings, etc. for rapid restoration of a line in the event of damage.

O. Construction and commissioning of substation control buildings, life support features, communication systems, security features, and yard equipment.

P. Design, construct, and test hardware and software required to integrate all substations and related control and monitoring equipment constructed under this contract into the NLCC SCADA system.

Q. Provide services to integrate remote control and monitoring of power flow through the transmission system and reactive power compensation system components constructed under this contract into the NLCC SCADA system.

The work shall be performed on a turnkey basis. The Contractor shall execute all temporary and permanent work, whether particularized in these Specifications or not, necessary for a timely and successful Taking-Over of a complete, functioning transmission line. The Taking-Over shall be within 18 months from the date of commencement of the Works plus 2 additional months for testing and commissioning for only the substation contractor performing Contract 1B.

1.2 General Requirements

1.2.1 Code, Standards, Specifications

All material used, plant supplied and all workmanship and tests shall be in accordance with the latest editions of IEC and ISO Standards, or where International Standards are not applicable, with national standards such as ASA, ANSI, ASTM, BS or VDE + DIN, IEEE, ASCE. Where such standards and codes are national or relate to a particular country or region, other authoritative standards that ensure substantial equivalence to the standards and codes specified or in accordance with technical requirements of a Country where the site is located, will be acceptable. For any such standards which are not written in the English language, the Contractor shall make available copies of a certified English translation thereof.

Where standards do not exist, as in the case of patent or special materials, all such materials and workmanship shall be of the best quality and full details of the material and any quality control tests to which they may be subjected, shall be submitted to the Engineer for approval.

The Contractor shall deliver (soft copy and hard copy) at his own cost, one complete set of the selected and approved international code standards, and specifications to the Employer / Engineer within 28 days after commencement of the works. The set shall contain codes, standards and specifications as referred to in the technical specifications or approved alternatives. One set shall be kept at the Contractor’s site office and shall be accessible to the Employer or his representatives during working hours.

1.2.2 Plant and Materials

All plant and materials to be incorporated in the works must be new, unused, and of the most recent or current models, and must incorporate all recent improvements in design and materials unless provided for otherwise in the Contract. Where applicable, all plant shall be of design suitable for adverse climatic conditions as experienced on site in Afghanistan. All plant shall be inspected and tested in full, to prove compliance with the requirements of the Specifications to the satisfaction of the Engineer.

1.2.3 Workmanship

All work, method statements of work and workmanship, whether fully specified herein or not, shall be of the highest order. In all respects, the generally accepted requirements and commonly recognized good practice for first-class work of this nature are to be adhered to and the Contractor shall submit quality certificates for materials. Method statements shall be submitted for all works for review and approval before the work commences and shall be to the satisfaction and approval of the Engineer.

1.2.4 Design and Engineering

The Contractor shall design, manufacture, supply, erect, construct, install, test and commission all Plant and Materials, items and components of the Works, and carry out all installation services and work necessary so that the Works described herein shall be satisfactory for their intended purpose.

The Contractor shall design the complete Works in accordance with the design criteria and specifications given in the Supply Requirements, and as shown in the Bid Drawings. All design carried out by the Contractor shall comply with these Specifications and shall take into account all requirements of the Facilities and technical requirements of Afghanistan. The Contractor shall optimize the design of each component of the Works in order to achieve the most economic design. The Contractor shall be entirely responsible for all design carried out by him.

The Contractor shall inform themselves fully of the actual dimensions, levels, etc., of any other existing or proposed structures before commencing the manufacture of parts dependent on such data. The design calculations for each member forming part of the Plant shall be based on the most unfavorable combination of all the loads which the said member or part is intended to support or assist in supporting either permanently or temporarily. All design calculations shall be subject to the review and approval of the Engineer.

Where appropriate design criteria or specifications are not indicated in the supply requirements or shown in the Bid Drawings, then the Contractor shall carry out the design work in accordance with generally accepted engineering design theories, principles and criteria, to the satisfaction of the Engineer.

The Contractor shall provide the Employer with fully detailed design drawings, detailed design reports and design calculations relating to the Works. All design work shall be subject to the approval of the Employer, pursuant to the Conditions of Contract. Design drawings, design reports and design calculations shall be prepared and submitted in accordance with chapter Documentation of the General Requirements.

1.2.5 System Characteristics and Climatic Conditions

All plant shall be designed for efficient operation under Afghanistan's climatic conditions, which can be harsh with snow and ice in winter and hot and dusty conditions in the summer. The following system characteristics and climatic conditions data are provided for guidance in designing the plant:

Specified clearances shall be considered minimums. The supplied values are elevation dependent and have been provided for information only. The designer shall consider elevation and adjust clearances tendered and applied to equipment design.

Table 1.2.1 Plant Design Conditions

Plant Design Conditions	
HV Transmission System	
Nominal Voltage (U_n)	**220kV**
Highest System Voltage (U_{max})	245kV
Design Voltage (U_m)	252kV
Standard frequency	50Hz
Rated short time current	40kA/3sec

Plant Design Conditions	
System configuration	Single Circuit, 3 phase/Circuit
Number of Conductor	1 conductor per phase
Earthing	Solidly Earthed
Insulation Coordination	IEC 60071-1
Number of OPGW	1 OPGW
Rated impulse withstand (peak)	
0m – 1,500m a.m.s.l.	950kV
1,501m – 2,500m a.m.s.l.	1,050kV
Rated 1 min power frequency withstand (kV rms)(peak)	
0m – 1,500m a.m.s.l.	395kV
1,501m – 2,500m a.m.s.l.	460kV
Phase-to-earth air clearance	
Minimum	1,800mm
0-750 m a.m.s.l.	2,100mm
751-1,500 m a.m.s.l.	2,300mm
1,501-2,500 m a.m.s.l.	2,500mm
Creepage distance outdoor	25mm/kV
Vector group of feeding transformers	YNd5 and YNd11
MV (20kV) distribution system	
Nominal Voltage (U_n)	20kV
Highest System Voltage (U_{max})	24kV
Design Voltage (U_m)	24kV
Standard Frequency	50Hz
Rated Short Time Current	12.5kA/1 sec
System Configuration	3 phase/3 wire
Earthing	Solidly earthed
Insulation Coordination	IEC 60071-1, -2
Rated Impulse Withstand (peak)	125kV
Rated 1 min Power Frequency Withstand (rms)	50kV
Minimum Phase-to-Earth Air Clearance	320mm
Creepage Distance Outdoor	25mm/kV
Vector Group of Feeding Transformers	YNyn0d11
LV Distribution System	
Nominal Voltage (U_n)	400/230V
Design Voltage (U_m)	0.6/1kV
Voltage Variation	±7.5%
Standard Frequency	50Hz
Rated Short Time Current	12.5kA/1 sec
Earthing	Solidly earthed

Plant Design Conditions	
Climatic and Geographic Conditions	
Seismic Factor for design Data not available	(Contractor to nominate value)
Altitude (Project Area only)	3,400 meters to 3,600 meters
Dry Period	June to November
Rain Period	December to May
Annual Rainfall	930mm
Air Temperatures:	
Average	3°C
Maximum	34°C
Minimum	-28°C
Humidity	
Average humidity summer	35%
Average humidity winter	75%
Thermal Resistivity of Soil:	
Average	1.2°C m/W
Maximum	3.0ºC m/W
Maximum Solar Radiation	1,200W/m2
Wind:	
Maximum Wind Velocity	41m/s (148km/h)
Wind and Dust	Sand and dust storms in summer
Isokeraunic Level Thunderstorm	23 days/year

1.2.6 Language

The English language shall be used in all Contract documents and in all correspondence between the Contractor and the Engineer, and between the Contractor and the Employer.

1.2.7 System of Units

In all correspondence, in all technical schedules and on all drawings, metric units of measurement, System International (SI) system of units, shall exclusively be used:

- Dimensions in meters and millimeters unless specified otherwise.
- The unit of mass is the kilogram (kg).
- The unit of force is the Newton (N).
- Angular measurement shall be in degrees, with 90 degrees comprising one right angle.

1.2.8 Documentation

1.2.8.1 General

The sizes of all documents and drawings shall conform to the ISO standard, and be of size A1, A2, A3 or A4. Larger sizes than A1 shall be avoided. All documents in size A3 and A4 shall be bound in hard covers. The schematic diagrams, apparatus and cable lists shall have a size of A3 or A4. The Contractor shall submit the hard copy and soft copy of the all documents as per the specification and price schedule.

All drawings shall be prepared and submitted in the latest version of AutoCAD or a similar computer aided drafting software package. Scales to be used on the drawings shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

Operational and warning labels in the Afghan language of Dari shall also be indicated.

The Contractor shall, during the project duration, maintain a List of Documentation to be updated whenever needed. The List of Documentation shall include the date of the original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for the submittal of the documentation.

1.2.8.2 Documentation for Design and Manufacture

During the design period, full documentation on all plant equipment shall be supplied to the Engineer and to the Employer for review and approval. All drawings prepared by the Contractor shall be submitted in five (5) sets hard copy and two sets (2) of soft copy (CD) to the Employer for review and approval. All documentation shall have such information or instructions related to the drawings and the design as may be necessary.

Within twenty eight (28) days after receiving such drawings, calculations, samples, patterns and models, one copy of each document will be returned to the Contractor, dated, signed and marked by the Engineer and, where necessary, with proposed corrections indicated.

Any delay arising out of failure by the Contractor to rectify the design, calculations, drawings, etc. in good time should not alter Contract completion date.

Drawings marked **RETURNED FOR CORRECTION** shall be corrected by the Contractor and sent to the Engineer for further review.

When a drawing is marked **REVIEWED** or **REVIEWED AS AMENDED**, the Contractor will be allowed to use the drawing for manufacture and erection. The Contractor shall, however, make corrections according to the remarks given by the Employer, Engineer, expert and upon their approval, the Contractor could use the drawings. Manufacturing starting prior to receipt drawings marked REVIEWED or REVIEWED AS AMENDED is done at the Contractor's own responsibility.

The Engineer’s approval does not however 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 Engineer’s approval shall not relieve the Contractor from full responsibility from mistakes or omissions therein or there from (including any resultant mistake or error in the Works) or for any discrepancy or deviation from the Technical Specification and other drawings.

Calculations, samples, patterns, models, etc., submitted to the Engineer for his review, shall be such as are called for herein or as may be necessary for proving compliance with the Contract.

1.2.8.3 Documentation for Installation

The Contract Price shall be deemed to include illustrated installation, operating, service and maintenance instructions for the Works, which shall be written in English. The installation, operation, service and maintenance manuals shall cover all aspects of the Works, including the civil works and structures, surface water drainage, sub-soil and under-structure drainage, etc., and all electrical equipment supplied. Hard copy and soft copy of the Method Statement with drawings/sketches shall be submitted for review and approval to Employer/Engineer for construction, erection, installation, etc. works.

The manuals shall include parts catalogues, and details of equipment installation, operation, maintenance and repair. If the manufacturer's standard bulletins are supplied, they shall be clearly marked to indicate the specifications applicable to the particular equipment that is supplied. Each manual shall include a full set of assembly drawings, including wiring diagrams, reduced to A3 size. The manual shall also contain a detailed service program adapted for each plant for all equipment explaining what action shall be done on which equipment and when.

Prior to the installation period the Contractor shall distribute copies of the REVIEWED documents and such other particulars, to the Employer in four (4) sets and to the Engineer in one (1) set.

The Contractor shall submit in due time but not less than one month before commissioning, two copies of preliminary Operation and Maintenance Instructions and Service handbooks to the Engineer for review and approval, following the same procedure as for the drawings.

The approved documentation shall be distributed in five (5) sets to the Employer two months before the start of commissioning.

If any descriptive brochures forming part of this documentation shall be provided in English versions, complete translations shall be enclosed.

The documentation shall continuously be updated during the installation and test period by the Contractor. During the initial period of operation, before receipt of As-built documentation at the site, one copy of the updated erection documentation, instructions, etc., shall be kept at the site.

1.2.8.4 Commissioning and Completion Report

Prior to the issue of the Taking-Over Certificate, the Contractor shall submit to the Employer's Representative one original and six copies of a Commissioning and Completion Report for each Section of the Works. The Works, or, if applicable, the Section, shall not be considered to be completed for the purposes of taking-over until such Commissioning and Completion Reports have been submitted to the Employer's Representative.

1.2.8.5 As-Built Documentation

GENERAL
Immediately after the Operational Acceptance of the Facilities, the Contractor shall update all final documents in accordance with the modifications made. When a document contains all modifications, it shall be marked As-built.

As-built documentation shall be submitted to the Employer in four (4) sets and to the Engineer in one set, at the latest two months after Operational Acceptance of the Facilities.

For drawings, A3 size and larger, one of the sets issued to the Employer, shall be of reproducible transparent material (PVC). In addition two soft copies, CD ROMS or similar computer storage media, shall be supplied for all As-Built drawings.

The supply of As-built documents shall comprise but not be limited to all AutoCAD 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.

GENERAL MANUALS
The following general manuals, covering the whole project, shall be delivered:

- A general description of the equipment in this contract
- Operating instructions, suitable for training of personnel
- General maintenance instructions, describing frequencies and methods for regular inspections, for planned maintenance and for regular part replacements. The instructions shall also include fault location guides.
- The manuals shall include spare part lists and description of any special tools needed for service of the equipment.
- All other drawings or manuals that are not mentioned, but are deemed necessary for a safe and proper handling of the delivered equipment.

PLANT DESIGN DOCUMENTATION
The following documents shall be delivered:

- All layouts, construction and installation drawings
- All design, calculations, regarding civil, electrical and mechanical design data and computations
- Design Drawings, Sag and Tension Chart, tower schedule, tower spotting data, etc.

PLANT DOCUMENTATION
Documents for approval shall be delivered before the work is started but shall also be included in the as-built documentation as follows; in case of alterations agreed upon by all parties, new documents shall be issued:

- Type test certificates for important plant; data specifications on other plants
- Routine test certificates
- Data lists with 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
- Dimension drawings. They shall be regarded as binding for the manufacturer and shall contain measures, weights and features of the plant
- Detail drawings as required by the Engineer

1.2.9 Progress Reports

Work plans, monthly programs and reports shall be provided by the Contractor. At the end of each month, the Contractor shall submit suitable written progress reports to the Employer and Engineer with the progress of design, manufacture, delivery, transport, erection, etc. If the progress of the Works does not conform to the approved Program, the Contractor shall indicate these deviations, with substantiating reasons. Regardless of the nature of the substantiating reasons, they do not relieve the Contractor from its responsibility for timely completion of the Contract, unless a change to the Contract is executed by the Employer, or unless a revision to the Program is formally published by the Employer.

1.2.10 Manufacture

Before commencing any manufacture of the Plant, the Contractor shall submit for the approval of the Engineer, the drawings of the manufacturers of the plant. After such approval has been given, the manufacture shall be planned and performed according to the Specifications and to the satisfaction of the Engineer.

The Engineer shall be afforded every opportunity to control and inspect the manufacture and testing of materials in the steelworks, rolling mills, foundries, factories etc., and their assembly in the workshops of the Contractor and his Subcontractors.

1.2.11 Site Regulations and Safety

The Employer and the Contractor shall establish Site regulations according to the General Conditions of Contract.

The Contractor shall provide appropriate training in handling plant and machinery to the workers and laborers before the commencement of work. All workers employed by the Contractor shall be insured against any accident.

1.2.12 Notices and Permits

The Contractor shall give the requisite notice and obtain any necessary approvals from the Government or Authorities. Authorities' Inspectors may be required in the case of excavations, trenching and (in particular) blasting operations; the Contractor shall pay for all permits required prior to and during the execution of the Contract, including those required for all temporary works.

1.2.13 Verification of Dimensions

Before work is commenced on any structural element required to be fabricated, or provided under this Contract, the Contractor shall verify by measurement on site, the relevant dimensions of all work previously completed.

1.2.14 Site to be Kept Tidy

Throughout the progress of the Works, the Contractor shall keep the site and all working areas in a tidy and workmanlike condition, and free from rubbish and waste materials. Other items, which at the present time are not required for use by the Contractor, shall be dispersed about the site in an orderly fashion, or shall be properly and securely stored.

The Contractor shall not mobilize and demobilize of any construction plant, materials, etc. from the site without the approval of the Employer or Engineer.

1.2.15 Site Supervisors

The Contractor shall provide the services of competent specialists to supervise the construction of the Works and erection / installation of Plant at the Site. The Contractor's Site Supervisors shall be given full responsibility and authority to negotiate and agree points arising out of the Works, in order that the Works may proceed with a minimum of delay.

1.2.16 Safety of Personnel

The maximum safety, consistent with good erection/installation practices shall be afforded to personnel directly engaged on this Contract, or to persons who, in the normal course of their occupation, find it necessary to utilize temporary works erected by the Contractor to access the working area.

Once any section of the Works or Plant has been energized, the Contractor shall establish a system for ensuring the safety of personnel and plant. While the Works, Plant are under the control of the Contractor, the Contractor shall be primarily responsible for the safety precautions. While the Works, Plant are under the control of the Employer, the Employer shall be primarily responsible for these precautions.

1.2.17 Packing and Transport Marking

All parts of the Plant shall be well packed and protected against loss or damage during the transport by sea and land and whilst in storage under adverse climatic conditions. All packing shall be performed in such a way that the plant will not be damaged by overturning of the packages or by weather. Dimensions of packages, crates, etc., shall be suitable for road transport. Instructions for handling shall be clearly marked on all parts, packages and crates.

All parts, packages and crates shall be adequately marked to enable identification. Each item contained in a package shall be clearly identified on the packing list by its description and part number and assembly drawing reference, and each item shall be marked or labeled to correspond with the packing list. The marking system to be used shall be as instructed by the Engineer.

All packages shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked with signs showing ‘up’ and ‘down’ on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precautions shall be taken to prevent rusting of steel and iron parts during transit by sea or storage on land.

The cost of all plant needed for the temporary fixing and supporting of the various parts of the Plant and the various packages to crane hooks, etc., during handling, transport and storage and the cost of load distribution beams, etc., where they form part of the packing or crates, shall be included in the Contract Price.

The Contractor shall be entirely responsible for all packing and any loss or damage shall be made good by the Contractor and, except where otherwise provided, at the Contractor's own expense.

Identification, reinforcement or upgrading of roads/bridges for access to the site and for transport of plant and materials shall be the responsibility of the Contractor. Any costs associated with identification, reinforcement and upgrading of roads and bridges shall be deemed to be included in the Contract Price.

1.2.18 Corrosion Protection and Painting

1.2.18.1 General

All parts of the Plant shall be protected against corrosion under service conditions. The protection shall also prevent corrosion during transport, storage and erection. Because of the high humidity at the Site, the protection shall be carried out at the Contractor's workshop.

Damage to the protection during transport, erection, etc., and erection joints, shall be repaired to the same quality as specified for the plant item.

1.2.18.2 Surface Protection

All steel and iron surfaces to be painted shall be prepared by means of sand or shot blasting or other approved methods. Before being blast-cleaned, the surfaces shall be cleaned of oil and grease. The surfaces shall be of clean metal and shall be dry and free from any foreign matter at the time of painting.

All surfaces to be painted shall be smooth, even and free from dirt, rubbish and shall be dry and protected from dampness; i.e., surfaces shall be free from anything that will adversely affect the adhesion or appearance of paint or galvanizing.

All defective concrete/cement plaster shall be cutout and trimmed, holes in internal plaster faces shall be made good with approved material. All dirt and powdery substrate shall be removed with slightly damp cloth.

All laitance shall be removed from concrete surfaces by wire brush or blasting. All holes, defects shall be filled and repaired by epoxy grouts. All dust and/or mill scale etc. shall - if necessary - be removed from new metal surfaces with a wire brush, chipping hammer or grinding. The surface of the metal work shall then be primed with an approved metal primer before application of the undercoat.

Pre-treatment of the galvanized surfaces includes etch-cleaning, sweep blasting (preferred) or emery paper used to clean and roughen the surface, remove any matter detrimental to the adhesion and to achieve a better anchor pattern.

Wood surfaces shall have all ironwork removed prior to the preparation of surfaces and re-fixed upon completion of the paint. All knots and resinous parts in wood surfaces shall be treated by two coats of shellac varnish. Cracks and holes shall be treated by one coat of primer and filled with approved filler.

1.2.18.3 Painting

The painting shall be carried out in an efficient and professional manner to the satisfaction of the Engineer. The quality and colors as well as the application of the paints shall be approved by the Engineer and the Contractor shall submit detailed information, samples and the Manufacturer's recommendations for the paints for approval.

Emulsion paints shall be used for internal cement plastering and internal fair-faced concrete of walls and ceilings. All emulsion paints shall be washable consisting of:

- One coat of Acrylic primer sealer
- Two coats of filler based on alkaline resistant polyvinyl-acetate
- Two coats of polyvinyl-acetate emulsion flat finish

Oil paints shall be used for wood surface and internal cement plastering and internal fair faced concrete in confined humid areas such as bathrooms, consisting of:

- One coat of Acrylic primer sealer
- Two coats of filler, based on alkaline resistant polyvinyl-acetate
- Two finish coats, based on alkyd resins

Varnishes shall be used for wood surfaces and shall be of one of the following types:

- Polyurethane varnish
- Synthetic varnish of linseed oil alkyd resin

All un-galvanized external surfaces except nuts, bolts and washers which may be removed for maintenance purposes shall be painted at the manufacturer's works as follows:

- A primary coat of rust-inhibiting paint.
- Two coats of non-glossy oil and weather resisting paint, the second of which shall be applied on completion of work tests.
- One final coat of aluminum, oil and weather-resisting non-fading paint.

The total thickness of the above coatings shall be minimum 160µm for outdoor surfaces and 120µm for indoor surfaces.
Other paint systems:

- Epoxy paints for concrete shall be as per the specification.
- Oil resistant paints shall be epoxy paint resistant to all types of oil.

Paints for steel and galvanized surfaces are specified under "General Technical Requirements Mechanical".

APPLICATION OF PAINTS (GENERAL)
All paint application shall be done in line with the paint manufacturer's instructions. Before applying any paint, all prepared surface shall be dry and clean. All priming paints shall be applied by brush except for etch primer which may be applied by brush or spray. Paints shall be applied as evenly as possible to provide a smooth coating of uniform thickness. Damaged areas of priming coats or undercoats shall be made good before further coats of paints are applied. The various coats of paint shall be distinguishable from each other by their shade.

The Contractor shall inform the Engineer in good time before starting to apply the next coat so that the Engineer shall have the opportunity of approving the previous coat. Painting systems shall not be carried out at temperature below 5°C or above 35°C. Trial coats shall be prepared at the request of the Engineer. The Contractor shall, upon completion remove all paint where it has been spilled, splashed or spattered on surfaces including sanitary fixtures, glass, and hardware. It shall be removed without marring the surface finish of the item being cleaned.

1.2.18.4 Galvanizing

Except where otherwise specified, all ferrous parts shall be galvanized. The dry film thickness or galvanization thickness on steel shall be measured by means of a magnetic or electrical thickness gauge such as "Microtester" or "Elcometer", and recorded in a tabulated form, indicating each layer of coat and the total dry film thickness. Contractor is responsible to provide such instrument without any charge to the Employer.

Galvanizing shall be applied, not less than 98% of which must be pure Zinc. The galvanizing procedure shall be started only after having finished all chipping, trimming, fitting and bending. Also, all drilling, punching, cutting and welding shall have been completed and all burrs removed.

All steel, including bolts, nuts and washers, shall be galvanized at the manufacturer's premises by means of hot dipping in accordance with internationally recognized standards such as ASTM A 239, or equivalent. The Zinc coat applied shall conform to ASTM A-123, minimum thickness grade 85 and higher (see table 2, ASTM A 123-89a).

Galvanizing shall consist of a continuous coating to minimum weights (g/m^2) as follows:

Rolled steel exposed to the atmosphere only	600g/m^2
Rolled steel under the ground surface	1,500g/m^2
Cast iron and malleable iron	600g/m^2
Bolts, nuts and washers	375g/m^2

The zinc coating shall meet the requirements according to BS 729, ASTM, A123, A153, A239 and A385, DIN 50961, 50976, 50978 or other equivalent methods and international standards. All steel shall be fully fabricated before galvanizing, no machine or shop work, boring, punching, etc., will be allowed after galvanizing.

1.2.19 Structural Steel and Cast Iron

Structural steel shall be made by the open-hearth basic oxygen or electrical furnace process.

In order to reduce the risk for material confusions, only two strength classes may be used. Suitable classes are low tensile steel: 280N/mm^2 (Grade 40) and high tensile steel: 420N/mm^2 (Grade 60).

Steel shall comply with the requirements of ASTM A143 and embrittlement tests shall be made in accordance with that specification. The Contractor shall test samples of steel materials at an approved laboratory in Afghanistan in the presence of Employer's QA Engineer before shipment to the site.

If the Contractor intends to use more than one quality of steel, they will be required to take every precaution to the satisfaction of the Engineer, against any possible intermixing of different qualities during transport, storing, handling manufacture and installation.

Cast iron shall have a tensile strength of at least 140N/mm^2. It shall be made from the best grey pig and scrap iron, and shall be close-grained, tough and uniform in character.

Malleable iron shall be of the black hearth type with a tensile strength of not less than 330N/mm^2.

1.2.20 Copper, Aluminum Alloys and Clad Steel

Copper and aluminum stranded conductor material shall meet the requirements of IEC Standards. The specification of proposed aluminum alloys shall be submitted for approval.

The preferred aluminum-clad steel to be supplied is Alumoweld or substantially equivalent. The preferred copper-clad steel to be supplied is Copperweld or substantially equivalent.

1.2.21 Marking

A legible mark of origin shall be applied on all castings and forgings, particularly on conductor and overhead ground wire hardware, and on insulators and associated hardware. Insulators shall, in addition, be marked with the mechanical or electromechanical failing load or a corresponding code number. Each separate member of the structure shall be marked indicating tower/pole type and number and the piece corresponding to the shop drawings. These marks shall be embossed into the steel before galvanizing, or concrete as part of the casting, in such a manner as to be plainly visible after manufacture.

1.2.22 Concrete Works

1.2.22.1 General

In general, and except where otherwise specified, the Contractor shall supply all labor, materials and plant required for the concrete work and all tests thereon and shall:

- Nominate the sources of materials, testing and mix design
- Mix, transport, place, compact, finish and cure all concrete
- Erect and dismantle all forms and formwork
- Produce and install all steel reinforcement
- Embed, as required, all items, whether supplied and erected directly or by other Contractors, in accordance with these specifications and drawings.

1.2.22.2 Cement

The type of cement to be used shall depend on the constructional circumstances and on the prevailing local conditions. Ordinary Portland cement, ASTM C-Type I, may be used at places not exposed to chemical aggressiveness. Moderate sulphate resistant cement and highly sulphate resistant cement shall be used as per the recommendation of the soil investigation reports and written approval of Engineer and the Employer. No extra payment will be made to the Contractor for the use of sulphate resistant cement.

Cement shall be delivered to the site in bulk cement containers or in sealed bags clearly marked with the maker's name and shall be carefully stored in a waterproof shed with a raised floor or in a silo of approved design. Each consignment of cement shall be stored apart from earlier consignments and the cement shall be used in the order in which it is delivered.

The Contractor shall ensure that each consignment is accompanied by a certificate from the manufacturer certifying that the cement in that consignment is in accordance with the Specification. Weathered or congealed cement, or cement more than three (3) months old after production, shall not be permitted to be used unless otherwise approved by the Engineer after the quality test.

Cement shall be stored in a suitable weather-tight enclosure on a board platform raised off the ground. The enclosure should be such that free circulation of air around the bags of cement is kept to a minimum. Any cement that has become damp, caked or lumpy shall not be used. Concrete batching operations shall be organized so that cement that has been manufactured first is used first.

Each consignment of cement may, after delivery to the site and at the discretion of the Employer, be subjected to the whole of the tests and analyses required by the standard Specification.

The Employer may reject any cement as a result of any tests thereof, notwithstanding the manufacturer's certificate. The Contractor may also reject cement which has deteriorated owing to inadequate protection or other causes or in any other case where the cement is not to his satisfaction. The Contractor must remove all rejected cement from the site without delay and expenses for the Employer.

The Contractor shall arrange for these tests to be carried out at his own expense.

1.2.22.3 Aggregates

All aggregates to be used for the Works shall be crushed rock type complying with the requirements of BS 882 or equivalent in all respects and shall be subject to the tests laid down in BS 812 or equivalent. The Contractor shall furnish to the Engineer samples of both the proposed fine and the coarse aggregates, together with such full details as the Engineer may require. No aggregates may be used in the Works until approved by the Engineer.

During the work, the Engineer shall order such tests he may consider necessary on the aggregates; any aggregates found to have unsuitable characteristics at any time shall not be used in the Works and shall be removed from the Site. Aggregates are subject to the Employer’s approval.

The various fractions of fine and coarse aggregates shall be stored separately and in such a manner as to avoid the admixture of dirt in the concrete. Aggregates shall be handled in such a way that separation is avoided.

Maximum size of aggregate used in concrete shall not be more than 20mm. The combined aggregate shall be as coarse-grained and dense-graded as possible. Fine and coarse aggregates shall be stored so that they are kept clean and free from contamination and are not subjected to segregation. Where a clean hard surface is not available for the stockpiles, the bottom 150mm of the aggregate piles that are in contact with the ground shall not be used.

1.2.22.4 Grading of Aggregates

The grading of the fine and coarse aggregates shall be such that when they are mixed in the proportions decided for each class of concrete, the grading of the combined aggregate shall be suitable for making dense concrete of appropriate workability, containing the proportions of cement and water prescribed.

The proportions of fine and coarse aggregates and the maximum size of the coarse aggregate to be used in each class of concrete shall be approved by the Engineer.

The Contractor shall be responsible for mixing the aggregates in the proportions approved by the Engineer for each class of concrete and each section of the work. He shall submit samples of the concrete material to the Engineer and the Employer well before starting any concrete work, and have test cubes made and tested from the aggregates and the cement which he intends to use. Concrete works must not begin until such samples and tests are to the Engineer's satisfaction.

Fine aggregate (sand) shall consist of clean material or manufactured sands and coarse aggregate shall consist of clean gravel, crushed gravel or crushed stone. Both the fine and coarse aggregates shall comply with ASTM C33. Sulphate and sulphide shall be in such quantities that the whole proportion, in sulphur trioxide, be less than 1 percent of the mass. Prohibited aggregates include:

- Feldspathic or schistose rock
- Aggregates containing charcoals or their residues such as coke, ashes, clinkers, finders

1.2.22.5 Water

The water to be used for mixing and curing of concrete shall at all times be kept clean and free from deleterious materials such as oil, acid, alkali, silt, etc. which effects to the cement, aggregate or the steel reinforcement. Water chemical analysis tests shall be carried out before commencement of foundation works.

1.2.22.6 Admixtures

No admixtures shall be used without written approval of Engineer and the suitability of admixtures must be proven in trial mixes in presence of representative of Employer. If required to improve the quality of concrete (workability, finish and water tightness), water reducing and set retarding agents and plasticizers shall be used in accordance with ASTM C-494. Under no circumstances shall calcium chloride or any admixtures containing calcium chloride be permitted in the concrete.

Manufacturer’s recommendations and instructions concerning overdosing of additives shall be strictly observed and mixture containing chlorides shall not be used under any circumstance.

1.2.22.7 Concrete Mixing, Placing and Compaction, Protection and Curing

MIX DESIGN
Full details of the components forming the concrete mix proposed to be used by the Contractor shall be submitted to the Engineer for assessment least one (1) month before any concreting

operations are commenced. Once the proposed mix has been approved by the Engineer, it shall not be varied by the Contractor unless the Engineer's prior approval has been obtained.

No concreting shall be commenced in any portion of the work until the preparations and the concrete mix design have been approved, and permission been granted by the Employer.

The required minimum concrete class is a C 25 as per BS standard. The mix design of the concrete has to be approved, and its suitability proven in trial mixes at site. In case of use of ready mixed concrete, trial mixes may be waived if an earlier proven mix design is used.

The concrete mix shall be designed and tested and their submission shall include the following information:

- Source, nature and grading of both the fine and coarse aggregates
- Type and supplier of the cement to be used
- Proportions by weight of both the fine and coarse aggregates
- Weight of cement per cubic meter of concrete
- Water-cement ratio by weight
- Estimated slump of the mix
- Arithmetic mean compression strength of the mix at 7 days and 28 days using cube compression test samples, plus the standard deviation of the test strengths and the number of cubes tested.

Any admixtures specified for inclusion in the concrete mixes or that the Contractor intends to use in his mixes (and they have had the prior approval of the Engineer) shall be included in these trial mixes. The ratio of the weight of fine aggregate (sand) to the total weight of aggregates shall be between 0.35 and 0.50. The minimum cement content shall be 350kg/m^3 -400kg/m^3 and the maximum water cement ratio by weight shall be 0.45.

The Contractor shall allow for the cost of all such testing in his Tender as well as any further testing and additional reporting that the Employer/Engineer may require.

MIXING OF CONCRETE
All concrete shall be mixed in power driven mixers, approved by the Engineer. If required in some locations (i.e., a mixing machine transportation problem), volume basis will be allowed as long as careful controls are maintained and written approval from the Engineer has been received.

The concrete materials shall be accurately measured to ensure the production of uniform batches of concrete. The Contractor will be required to proportion the materials by weight at all times. If required, the materials may be measured by volume and the proportions in each batch adjusted to suit whole bags of cement after getting written approval from the Engineer. Only unbroken bags of cement may be used. Bags of cement that have partially set, contain any lumps, or have become wet at any stage shall not be used.

Volume measurement shall be carried out using well-proportioned gauge boxes. Under no circumstances will the volumes be proportioned by shovels. The gauge boxes shall be loose-filled with the material being measured then struck off level with a straight edge then discharged into the mixer. The required volume of mixing water shall be adjusted to allow for the free moisture contained in the aggregates. Personnel in charge of the concrete mixing operations shall be trained and experienced in this method of concrete production.

The batch mixture shall be rotated at a speed recommended by the manufacturer and all concrete shall be mixed for a minimum of 1½ minutes from the time the last of the materials have been placed in the mixing drum. The mixing shall continue until the materials are thoroughly and uniformly mixed and the concrete is uniform in color and texture. The entire batch must be discharged from the mixer before recharging commences. Each batch of concrete shall have a similar appearance. The slump of the concrete shall normally be between 25mm and 50mm corresponding to a stiff, plastic consistency.

All plant for mixing shall be cleaned and free from all dirt and debris. All mechanical equipment (mixture, vibrator, etc.) and the stock of construction material (cement, aggregate and sand) shall be checked before starting a concrete pour to ascertain whether or not it is in good operation condition and sufficient in quantity for the foundation work. The Contractor shall always have at least two vibrators in operating condition at the location of the concrete placement.

In hot weather conditions, various means should be employed to lower the temperature of concrete as:

- Using cold water; the use of ice is to be limited to chill the mixing water, but no ice is to be used during batching
- Avoiding the use of the hot cement
- Insulating water supply lines and tanks
- Cooling coarse aggregate
- Shading and/or cooling mixer drums
- Adequately watering of sub-grade, formwork and reinforcement
- Avoid concreting around midday
- The temperature of fresh concrete must in no case exceed +30°C

PLACING AND COMPACTION OF CONCRETE

Concrete shall be conveyed from the mixer to moulds by a method that prevents segregation or loss of the ingredients. It shall be placed as nearly as practicable in its final position to avoid segregation due to re-handling or flowing.

The placement of concrete shall be at such a rate that the concrete is at all times plastic and flows smoothly, ensuring that the concrete in its final position shall be dense and homogeneous.

The placement of concrete in the moulds shall be completed within ½ hour after the introduction or the mixing water to the cement and the aggregates in the concrete mixer. Batches in excess of 30 minutes of mixing the concrete shall be rejected and replaced by fresh concrete without any extra cost to the Employer. Each formwork shall be filled with concrete as a continuous operation. The written approval is required for construction (working) joints, if required.

Concrete shall be placed and compacted/vibrated in horizontal layers of not more than 300mm thickness each and vibrators and other compacting equipment shall be to the satisfaction of the Engineer.

When placing concrete in the foundations, with a fall over 1 meter, appropriate method must be adopted by the Contractor to prevent separation of concrete.

PROTECTION AND CURING

Cement-based repairs may require some initial protection, because rapid drying could halt the hydration of the cement and lead to shrinkage cracking, de-lamination and weakness.

Careful curing is essential by covering with absorbent material that is kept damp, preferably covered in turn by polythene or similar sheets, which are sealed at the edges. Shading from the sun may be necessary. Importantly, alternate wetting and drying must be prevented because of the alternating stresses that it would cause.

If repairs are to be carried out during hot weather, it is advisable to shade the work from direct sunlight in order to prevent drying out of cement-based repairs or over-rapid stiffening of resin-based materials.

Requirements for curing large volume repairs are similar to those for new construction. Although they are less critical in this respect than thin patches, curing is important to a durable result. Normal curing methods are usable except that sprayed-on curing membranes are suitable if a surface coating is to be applied later.

During the initial stages of hardening, the concrete shall be protected from the direct rays of the sun and from drying winds. The formworks containing the hardened concrete shall not be disturbed or give external forces.

To ensure proper curing, all concrete shall be kept moist for a period of at least 10 days. Foundations shall not be backfilled before they have been cured and inspected. The foundations shall not be subjected to any loads in addition to those existing at the time of the placing of the foundation concrete until the curing period has elapsed. Curing compound membranes shall be applied uniformly by spray, leaving no pinholes or gaps, at a rate not to exceeding 4.91kg/m/liter. The curing compound shall be applied after finishing operations are completed and surface moisture has disappeared.

1.2.22.8 Ready-mixed Concrete

Ready-mixed concrete may be used in the Works, provided that adequate control is maintained of the supply, mixing, and placing of the concrete.

Concrete shall be placed and compacted in its final position within 90 minutes of the water being added to the mix. If the Bidder/Contractor proposes the use of pumps for the transporting and placing of concrete, he shall submit a detailed method statement. The Contractor shall ensure that pumping shocks shall not be transferred from the pipeline to the form-work, to previously laid concrete or to the structure. The initial discharge of any pumped concrete shall be discarded completely.

1.2.22.9 Steel Reinforcement

The steel reinforcement shall consist of hot rolled deformed bars conforming to the requirements of Grade 60 ($420N/mm^2$) or higher. The specific number, type and location of ridges on the deformed bars shall be approved by the Engineer and the Employer.

The number, placing and fixing of bars shall be in accordance with the drawings and approved bar bending schedules, or otherwise, as directed by the Engineer.

All reinforcing bars shall be bent in accordance with the relevant standard. In particular, no reinforcement shall be heated. All reinforcement shall be rigidly fixed in position to the concrete cover specified by an approved means.

All chairs, tie-wires or other devices used to connect, support, secure or fasten reinforcement shall be provided as per the requirement and as directed by the Engineer.

All reinforcing bars shall be stored in a clean, dry place on platforms off the ground. Grease, oil, paint or any other substance that will affect the bond of the reinforcement shall not be allowed to come in contact with the bars. All such substances shall be cleaned off the reinforcement before it is placed for concreting.

All reinforcing bars shall have a protective cover of not less than 100mm at the bottom of footings and on any surface of concrete that will be exposed to salt water and 50mm for concrete exposed to weather or soil.

1.2.22.10 Formwork

The Contractor shall be entirely responsible for the design and construction of the formwork to be used for concreting.

The formwork shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in position.

All form-works shall be of such tight construction that slurry cannot flow out at the joints during pouring and compaction. If required, joints shall be sealed with foam rubber strips.

No concrete shall be placed until the Engineer or his representative has examined and approved the formwork.

1.2.22.11 Surface Finish

Unless otherwise shown on the drawings, all permanently visible concrete surfaces shall have a regular finish of uniform texture free from holes, pins and formwork.

Should any section of the concrete present a rough, uneven, honeycombed discolored or imperfect appearance when the shuttering is removed, it shall be chiseled to such a depth and refilled and properly refaced with such class of concrete as the Employer may direct.

In the event of excessive porosity being discovered, the defective area shall be chiseled and make well as specified above, all at Contractor's cost. No plastering of such concrete areas will be permitted.

Concrete foundation edges above the ground level and 300mm below the ground level shall be beveled by inserting 25mm triangular edges in the formwork.

Concrete foundation tops shall be designed and finished to prevent the accumulation of water.

Concrete surfaces shall be wood float or steel trowel finished as specified on the Drawings or instructed by the Engineer. All finishing works shall be carried out in accordance with the relevant specification of British Standard and to the satisfaction of the Engineer.

All concrete foundations shall be treated with an asphaltic or equivalent coating in order to be acid-resistant. The surface to be covered must be perfectly clean. The coating shall be applied on the formed surface of the foundation with a layer at least 2mm thick.

The required protective painting of foundations shall not be executed till the end of the curing period to obtain a completely dry surface. Painting shall be done according to the specifications of the supplier.

1.2.22.12 Fixing of Steel Structures

Where shown on the drawings or as directed by the Engineer, steel items shall be embedded directly in correct positions in primary concrete. All brackets, anchor bolts and other steel items, for which recesses in concrete have been made, shall be fixed by secondary concrete after careful alignment to correct positions.

1.2.22.13 Testing of Concrete

The Contractor shall design and test concrete mixes, which have 28 days cubicle compressive strength of 25N/mm^2.

All testing of concrete shall be carried out in accordance with the requirements of BS 5328: Part 4 and BS 1881 or equivalent. During the placing of concrete for each section of the work and at such other times as directed by the Engineer and the Employer, quality certificates of all materials shall be submitted and 3 sets of test cubes, size 15cm x 15cm x 15cm, shall be taken, each set consisting of 6 cubes. From each set 3 cubes shall be tested after 7 days and the remaining 3 cubes after 28 days. The compressive strength of the cubes shall not be less than 21N/mm^2 after 28 days.

Consistency and bleeding test and such other preliminary tests as the Engineer may direct, shall be taken as often as directed by the Engineer or Employer. No concrete of any type or class shall be used in the Works before the preliminary tests have shown specified compressive strength and workability

All test cubes shall be well marked and cured as specified.

1.2.22.14 Maintenance Tools and Plant

The Contractor shall include and supply all tools and plant with latest calibration certifications that are required for the normal operation and maintenance of the equipment being supplied under the Contract. All tools and plant shall be subject to the inspections and/or tests on the functions specified in the Supply Requirements and guaranteed in the approved drawings.

Instruction manuals of tools and plant shall be submitted for approval in the same manner as the installation operation and maintenance manuals and when finally approved, one original and three copies shall be prepared and forwarded to the Employer.

Each tool and plant item shall be clearly marked with its size and/or purpose and shall be packed in the appropriate box with three (3) sets of an operation and maintenance instruction book. All nameplates, duty labels and instruction plates on tools and appliances shall be marked in English.

1.2.22.15 Auxiliary Electrical Supply

The Contractor shall be entirely responsible for providing auxiliary electricity supplies needed on Site for construction and commissioning.

1.2.22.16 Temporary site Installation

The Contractor shall be entirely responsible for providing all temporary site installations of every kind that may be required for carrying out the works including the facilities concerning office, living accommodation, fenced storage areas, lockable sheds, installations for supply of industrial water, power and compressed air, etc. The Contractor shall plan all temporary site installations required for the works to the approval of the Engineer. After completion of the work, such temporary installations are to be removed and the site left clean.

All costs for the construction and/or supervision and the removal or handing over to the Employer of all temporary site installations shall be deemed to have been included in the price schedules.

1.2.22.17 Running Costs

The Contractor shall be entirely responsible for the running and maintenance costs throughout the period when the site works are being carried out, including all temporary site installation works.

The costs for running and maintaining the temporary site installations together with other running costs necessary for the satisfactory execution of the works shall be deemed to have been included in the price schedules.

1.2.22.18 Social Safeguards

The Contractor shall minimize the locations of transmission towers in agricultural and populated areas. Where routing of transmission towers across agricultural and populated areas is unavoidable, the tower locations shall be positioned to completely avoid houses, structures, and interference with social and cultural assets. The Contractor's detailed line route design will be reviewed and approved by the Employer, in consultation with any affected people, after verification of its land acquisition impacts.

1.3 Transmission Line Plant

1.3.1 Transmission Line Structures

1.3.1.1 General

The transmission line works includes the design, supply, and installation of about 1/2km of 220kV single circuit transmission line from the 220kV transmission line tap to the 220kV substation at Salang Tunnel. The transmission system shall be priced with design of a complete simplex conductor single 220kV circuit, construction.

The scope of work comprises manufacture, supply, delivery and erection of steel lattice single circuit towers for the said project. The towers shall be self-supporting, hot dip galvanized lattice steel types & design to carry the single circuit, simplex line conductors per phase, insulators, shield wire and all fittings under all loading conditions.

Outline diagrams of double circuit towers are included in section 4.0 of this specification. The design of the towers shall cater for leg extensions up to 8m in steps of 1m.

The transmission system design shall conform to conceptual design drawings included in Section 4.0 of this specification.

Specified clearances shall be considered minimums. The supplied values are elevation dependent and have been provided for information only. The designer shall consider elevation and adjust clearances tendered and applied to equipment design.

In order to save time for design and testing of the towers, the Contractor may propose an existing proven tower design, if it is equal to, or exceeds the design loading and clearances required by this Specification.

The members of the latticed structure shall be hot-rolled steel angle sections and shall be manufactured by an approved process. All tower material shall be factory made and entirely galvanized by the hot dip process.

The design of all supports, conductors, insulators, and fittings shall be such as to minimize the risk of damage or deterioration in service to any part of the transmission line due to vibration or climatic conditions.

The transmission line conductors shall be of type Aluminum Conductor Steel Reinforced (ACSR) “ZEBRA”, with a nominal aluminum cross-section of 400mm^2, or equivalent.

The OPGW ground wire shall be concentric-lay-stranded aluminum alloy/steel with an aluminum clad stainless steel tube housing for 24 fibers. The nominal cross-sectional area of the aluminum alloy/steel stranded conductor shall be 71.5mm^2 or equivalent.

1.3.1.2 Electrical Design

In addition to the requirements of System Characteristics and Climatic Conditions, the electrical characteristics of the 220kV transmission line shall be as stated below:

- Nominal current carrying capacity of conductor (ZEBRA) at 10^{o}C ambient and 75^{o}C conductor temperature 950A
- Maximum shielding angle to outer phase conductor 30°
- Minimum creepage distance 6,125mm
- Number of conductors per phase 1
- Conductor spacing (center to center) Not Available
- Nominal transmission capacity at 10^{o}C ambient and 75^{o}C conductor temperature for the longest day of the year 135MW

1.3.1.3 Mechanical Design

LATTICE STEEL TOWERS
The tower structures shall be of the self-supporting lattice type steel frame with square base. The general outlines of the basic tower types shall be as per the original existing designs, providing they meet the requirements of this specification.

TOWER TYPES
The normal tower types to be designed, manufactured, and supplied shall satisfy design requirements, included in this specification, and conform to outline drawings are required by this specification. The design of the towers shall cater for leg extensions up to 8m in steps of 1m.

PROVEN TOWER DESIGNS
In order to save time for design and testing of the towers, the Contractor may propose an existing proven tower design, if it is equal to, or exceeds the design loading and clearances required by this Specification.

DESIGN DATA-ASSUMPTIONS AND DETERMINATIONS
Wind Loads
The maximum design wind velocity in along the transmission line route is 41m/s which correspond to a dynamic wind pressure of 1,000N/m2. Reduction factors on the wind pressure, for increasing span length, shall be based on IEC 60826 - Design Criteria of Overhead Transmission Lines.

The coefficient of dynamic wind pressure shall be considered for all towers/conductors/ground wire according to IEC 60826. The dynamic wind pressure coefficient for the line conductor is 1.0. The dynamic wind pressure coefficient for the Insulator set is 1.2.

The total effect of wind on duplex conductors shall be taken equal to the sum of the wind load on each sub-conductor without considering any masking effect of one sub-conductor on the other.

Design Spans
The term "basic span" shall mean the horizontal distance between centers of adjacent supports on level ground from which the height of standard supports is derived with the specified conductor clearances to ground in still air at maximum temperature.

The term "wind span" shall mean half the sum of adjacent horizontal span length supported on any one tower.

The term "weight span" shall mean the length of conductor, the weight of which is supported at any tower at minimum temperature in still air. At a suspension position, the minimum weight of conductor supported shall not be less than 25% of the total weight of conductor in the two adjacent spans.

Design Loading Assumptions
The structures shall be designed to withstand the following load combinations as a minimum:

Table 1.3.1 Minimum Structural Load Combinations

Minimum Structural Load Combinations	
High wind at 90° angle to line	Maximum wind speed at a conductor temperature of +10°C
High wind at 45° angle to line	Maximum wind speed at a conductor temperature of +10°C
Exceptional conditions	Broken wire condition and longitudinal overload condition at +10°C final tension in accordance with IEC 60826
Construction and maintenance loads	Loading conditions according to the document specified above
	Combined ice and wind loads
	Lower altitudes – 5mm radial ice thickness, 100Pa wind, -5°C (glaze ice)
	Medium altitudes – 15mm radial ice thickness, 200Pa wind, -5°C (hard rime ice)
	High altitudes – 35mm radial ice thickness, 250Pa wind, -5°C (soft rime ice). Ice density, based on the different expected ice types, and related considerations shall be as per IEC 60826

Design Loading Requirements
The structure/line loading shall be as determined from all the relevant requirements of IEC 60826, and this specification. This includes factors on wind and the structures, security loads, component strengths including insulators and fittings and for the loading combination requirements above.

In case of conductor uplift, the cross arm of tension towers shall be designed accordingly and proven by calculations. Counterweights may be permitted on suspension towers.

Broken Wire Condition:

- Twin Conductor bundle circuits - Any two-phase bundles and one earthwire broken.
- Any three phase bundles or combination of two-phase bundles and one earthwire broken.
- As per clause 5.2.1 of IEC 60826, the Contractor shall account for the increased wind speeds due to funneling and sloping ground, affecting the line and structure loading.
- Conductors and Overhead Ground Wire (OPGW)

The following design limitations shall apply to conductors:

Table 1.3.2 Conductor Design Limitations

TEMPERATURE	WIND SPEED	TENSION SPECIFICATION
5°C	Still air	Initial tension not exceeding 25% of the UTS
25°C	Still air	Final tension not exceeding 20% of the

		UTS
75°C	Still air	Final sags under maximum temperature to be calculated at +75°C

Design limitations, in accordance with manufacturer's instructions but not exceeding the following, shall apply to OPGW:

Table 1.3.3 OPGW Design Limitations

TEMPERATURE	WIND SPEED	TENSION SPECIFICATION
5°C	Still air	Initial tension not exceeding 20% of the UTS
25°C	Still air	Final tension not exceeding 20% of the UTS
20°C	Still air	Final sag not exceeding 75% of initial conductor sag
55°C	Still air	Final sags under maximum temperature to be calculated at, +55°C

Loading Diagrams, Application Charts and Sag and Tension Charts
Using the loads, load factors and design limitations for a ruling span of 300m for the line, loading diagrams and application charts for each tower type, as well as sag and tension charts for the conductor, and overhead ground wire, shall be provided by the Contractor for approval by the Employer.

Seismic Considerations
The design of towers and foundations shall be checked for seismic forces under no wind conditions. The seismic acceleration shall be in all directions. The Contractor shall use the seismic factor for the project areas. For information, refer to seismic maps and drawings, Volume 2, Section 4.0F.

1.3.1.4 Clearances

Conductor Clearance to Ground and Objects on the Ground
The term clearance shall mean the minimum clearance and shall not be infringed under conditions of maximum sag at the selected conductor temperature. The minimum clearances between conductor and ground shall be maintained at a maximum conductor temperature of +75°C in still air, final sag tower spotting temperature and including creep.

Table 1.3.4 220kV Transmission Line

CLEARANCE ITEM	SPECIFICATION
Ground accessible to pedestrians only	7.5m
Ground in urban areas, road crossings and water without boat traffic	7.5m
Overhead lines crossing with voltages up to 1kV	3.0m
Overhead lines crossing with voltage > 1kV	4.6m
Telecommunication lines	3.5m
Trees	4.0m
Navigable water ways (above mean water level)	20m

The detailed clearances given in the Technical Data Sheet shall be observed within the overhead line area and up to 5m outside the outer phase. For other objects not listed in the schedule above, the requirements for minimum clearance shall comply with VDE 0210. In addition, 0.5m shall be added to the clearance values above, to allow for survey and drawing errors. Above minimum clearances shall be kept after final settling of conductors; i.e., including 5 years creep.

Ground wire sag shall not be larger than the conductor sag under any circumstances.

The distance from a tower foundation to the nearest part of a road shall not be less than 15m.

CONDUCTOR SPACING
To avoid phase clashing in spans, diagonal conductor-to-conductor spacing is to be checked to ensure a minimum spacing as derived from the following formula is met:

$$\sqrt{x^2 + (1.2y^2)} \geq 0.4 \times \sqrt{f + l} + 0.007 \times U$$

where:

x = projected horizontal distance in meters between conductors at midspan
y = projected vertical distance in meters between the conductors at midspan
f = final conductor sag at +75°C in meters
l = length of insulator set in meters
U = highest voltage in kV.

CONDUCTOR CLEARANCE TO TOWERS
The following clearances shall be maintained under the specified swing of insulator sets and jumpers:

Table 1.3.5 Conductor Clearance to Towers

Conductor Clearance to Towers	
Minimum clearance phase-earth at temperature +30°C; still air	1,850mm
Minimum clearance phase-earth at temperature +10°C; reduced wind (10m/s)	1,850mm
Minimum clearance phase-earth at temperature +5°C; (full wind 41m/s)	700mm

1.3.1.5 Crossing of Obstacles

The Contractor shall make all necessary temporary provisions and take all necessary precautions, including the erection of guard structures, as required where the line crosses roads, telecommunication lines, power lines or other obstacles to maintain the load of the public and to avoid damage. The Contractor shall notify the Employer and the owner of any such obstacle within a reasonable time before the Contractor intends to make the crossing. Power lines will normally be taken out of service and earthed, and remain de-energized during the time required by the Contractor to complete the crossing.

Before making the crossing, the Contractor shall obtain the Employer's and the owner's approval of the precautionary arrangements and installation methods intended for use, and the time required for the work.

When permanent reconstruction of obstacles, as indicated in the structure list, has to be performed the Contractor shall act as outlined above.

No additional payment will be made for temporary or permanent provisions according to above.

1.3.1.6 Structure Locations

The general transmission line routing is located as shown in Volume 2, Section 4.0. The detailed survey and tower spotting shall be performed by the Contractor and be approved by the Employer/Engineer. The line survey team shall include as a minimum surveyors, a transmission line design engineer, geo-technician, an Employer representative and a representative appointed by the local authority. It shall be the Contractor's responsibility to coordinate the members of the survey team including the Employer and local representatives. The price shall be included in the Contractor's contract price.

In each case, the new alignment shall be approved before finalizing structure scheduling. All costs involved in undertaking these investigations shall be borne by the Contractor.

1.3.2 Material Specifications – Conductors and Insulators

1.3.2.1 Standards

Conductors and insulators shall conform to the latest revision of the standards listed below, which shall be verified by a type test certificate issued by the manufacturer, not more than 5 years old.

IEC 60060	High voltage test techniques
IEC 60071-1	Insulation coordination
IEC 60120	Dimensions of ball and socket couplings of string insulator units
IEC 60305	Insulators for overhead lines with a nominal voltage above 1000V -Ceramic or glass insulator units for A.C. systems - Characteristics of insulator units of the cap and pin type
IEC 60372	Locking devices for ball and socket couplings of' string insulator units - Dimensions and tests
IEC 60383	Insulators for overhead lines with a nominal voltage above 1000V
IEC 60437	Radio interference test on high-voltage insulators
IEC 60797	Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric
IEC 60888	Zinc-coated steel wires for stranded conductors
IEC 60889	Hard-drawn aluminum wire for overhead line conductors
IEC 61089	Round wire concentric lay overhead electrical stranded conductors
IEC 61109	Composite insulators for A.C overhead lines with a nominal voltage greater than 1000 V - Definitions, test methods and acceptance criteria

1.3.2.2 Conductor and Overhead Ground Wire

CONDUCTOR
The conductor shall be of aluminum conductor steel reinforced (ACSR) construction and shall be manufactured in strict conformity with the latest edition of BS 215 Part 2 or in accordance with IEC 60888, IEC 60889 and IEC 61089.

The purity of aluminum shall be the highest commercially available and not less than 99.5% with copper content not exceeding 0.04%. The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made. Aluminum wires shall be made as per the latest BS 2627 and steel wires as per BS 4565. The maximum length of the cable shall not exceed 1.6km per drum.

The Employer reserves the right to verify the length of conductor in any conductor drum to be supplied by the Contractor.

Physical properties of the conductor as per the BS 215, Part 2:1970 are as follows and for detail refer the Technical Data Sheet:

- Code name ACSR “ZEBRA”
- Nominal Area 400mm^2

Payment for the supply and stringing of conductor shall be based on the horizontal route distance. The unit cost shall include wastage, sag length and jumpers. No extra payment shall be given for wastage, sag length and jumpers.

OVERHEAD GROUND WIRE OPGW

The optical power ground wire (OPGW) shall have a cross-section of nominally 71.5mm^2. The OPGW shall be a steel wire or aluminum clad steel wire with an OPGW composite fiber optic communication cable. The optical fiber cable, containing 24 single mode optical fibers shall be embedded loosely inside the protective tube. The protective tube shall be of aluminum alloy or stainless steel.

Fiber optic and stranding of OPGW shall comply with the following latest standards:

- Single mode Fibers ITU-T
- Optical Fiber Cables IEC 60793-1 & 2, IEC 1089/91, IEC 60889/87
- Stranding IEC 60104/87, BS 3242

All wires used in the manufacture of earthwire shall be free from protrusion, sharp edges, abrasion; no joints on the aluminum clad steel wires shall be permitted.

Consideration will be given to a slotted core design, unless alternatives provide similar crush resistance and everyday tension characteristics. Manufacturing, testing and delivery of conductors shall as a minimum be in accordance with ASTM B416.

The main optical characteristics of the OPGW are as follows; for details refer Technical Data Sheet:

- Outer Diameter 12.7mm (nominal)
- Nominal Cross-section 71.5mm^2

Payment for the supply and stringing of OPGW shall be based on the horizontal route distance. The unit cost shall include wastage, sag length, jumpers of the OPGW. No extra payment shall be given for wastage and sag length.

CONDUCTOR REELS/DRUMS

Conductor reels/drums shall be stored and transported in matched sets; i.e., approximately the same lengths of conductors shall be sorted and transported together to facilitate the handling and installation/sagging in phase conductor pairs. Ideally, the matched drums should contain conductor from the same winding machines in the factory.

The reels shall be of sufficient size and strength to protect the conductor or overhead ground wire and suitable for the tension stringing method. The flanges and the drum shall have such a design and smoothness that the conductor or the overhead ground wire is not damaged during winding and unwinding. Only one length of conductor shall be placed on each reel.

Plastic or equivalent material is to be provided between conductors or overhead ground wire and the reel and lagging.

Fiberboard lagging is acceptable provided it is placed between the flanges of the reel; otherwise, wood lagging is required.

The reels shall be plainly marked with a metal tag. Included in the marking shall be the manufacturer's details, factory reel number, destination and description, the actual length; the net, tare and gross weights; the contract number and arrows showing the direction in which the reel should be rolled and in which direction the outer end of the conductor points.

For tender purposes, it may be assumed that conductor supply will be on properly lagged, non-returnable wooden drums. Conductor reels and lagging shall be approved by the Employer before delivery.

1.3.2.3 Composite Long Rod Insulators

GENERAL
Suspension and tension insulators shall be of the long rod composite type and shall have a Y-clevis top fitting and ball bottom fitting, the insulation type shall be silicon rubber. The insulators shall comply with IEC 61109 and be supplied complete with a suitable corona ring and corona free nuts and split pins.

The insulators shall be of the puncture-proof type. These insulators shall be made of a core fiber glass-reinforced resin and shed of different plastic materials. They shall be of light weight and high tensile strength. They must withstand safely all operating stresses including Ozone and UV radiation.

The accessories for the insulators shall be matched to suit, in accordance with IEC 61109.

All materials, whether fully specified herein or not, shall be of first class quality and shall conform to the best modern practice and comply in all respects with these Specifications. The materials shall be free from folds, cracks and other exterior and interior defects that can affect its strength, ductility, durability or ability to function.

All materials shall be inspected and tested in full to prove compliance with the requirements of these Specifications and to the satisfaction of the Employer. The testing shall be carried out according to the relevant standards approved by the Employer.

Assembly shall be performed in such a way that the mechanical properties cannot be affected and to ensure that the insulating part is not subject to any mechanical stress due to pressure exerted by the bottom edge of the cap.

Free surface of insulating parts shall be cleaned of impurities.

Each insulator unit shall be marked with the name or trade mark of the manufacturer and the year of manufacture with means to ensure the system of traceability for each of the component parts. In addition, each insulator unit shall be marked with the specified electromechanical or mechanical failing load.

TESTING
Full and complete testing (Design Test, Type Test, Sampling Test, Routine Test) of all components shall be carried out in accordance with IEC 61109 (latest version) and to the satisfaction of the Employer/Engineer. The cost of any tests to be conducted shall be borne by the Contractor and deemed included in the contract price.

Type test certificates shall be issued by an internationally known, independent testing laboratory, which is located outside the country of the manufacturer. Said test certificate together with certificates from Routine and Sample Tests from a recent delivery shall be submitted with the bid.

The Bidder shall, if available, submit test reports regarding the power arc performance.

TYPE TESTS
The Bidder shall submit with the bid, type test reports for the tests specified below on similar insulators supplied under previous contracts. The type tests shall not be older than five years and in accordance with IEC 61109 (latest version).

SAMPLE TESTS
The Contractor shall carry out the sample test in accordance with IEC 61109. The Contractor shall keep the Engineer informed about the progress of manufacture of materials and works, so that the witness, inspection and testing can be performed in the presence of the Employer's representative.

Before every inspection and test supervised by the Employer, the Contractor shall assure the Employer that the work is in all respects is ready for inspection and testing, according to this Specification. The insulators which have been subjected to sample tests shall not be included in the delivery lot.

ROUTINE TEST
The manufacturer shall carry out routine tests as specified in IEC 61109 (latest version) at their own expense.

1.3.3 Design Requirements – Insulator Sets and Fittings

1.3.3.1 Long Rod Composite Insulators

GENERAL REQUIREMENTS FOR INSULATORS
Long rod composite insulators shall be used for both suspension and tension tower positions. Insulator sets shall have Y-clevis top fittings and ball bottom fittings. The 160kN insulators shall have 16mm pins and the 310kN insulators shall have 20 mm pins; pins shall be to IEC 60120.

RATING AND DESIGN
A minimum creepage distance of 25mm/kV shall apply to suspension and tension insulator strings throughout the length of the transmission line.

The design of insulators and fittings shall be such as to avoid local corona formation and discharge likely to cause excessive radio interference; all insulator fittings shall use corona free nuts with split pins or “nyloc” or similar torque nuts.

ASSEMBLIES FOR OVERHEAD GROUND WIRE
The tension assembly shall be attached to the structure comprising an adjustable device for changing the wire tension.

The overhead ground wire shall be connected to each structure by means of a jumper connected to the overhead ground wire with a parallel clamp, and to the tower with an earthing clamp.

Assemblies shall ensure the integrity of the optical fibers is maintained for all loading conditions.

1.3.3.2 Hardware

GENERAL

Clamps and fittings shall be of a design approved for the conductor according to the relevant clause.

All hardware shall provide the same ultimate strength as the chosen insulator.

The earthed end of suspension and tension insulator sets shall be electrically attached to the tower as well as mechanically attached.

The corona free connecting attachments, including bolts, nuts and washers, shall be included in the insulator assemblies.

The earthed end of tension sets assemblies for the overhead ground wire shall be attached to the tower by means of articulated connectors. The tension set shall comprise a device for adjusting the conductor tension. All materials, whether fully specified herein or not, shall be of first class quality and shall conform to the best modern practice and comply in all respects with these specifications.

All materials shall be free from folds, cracks and other exterior and interior defects which can affect its strength, ductility, durability, or ability to function.

All materials shall be inspected and tested in full, to prove compliance with the requirements of the Specifications and to the satisfaction of the Employer.

The testing shall be carried out according to the relevant international standards, or approved by the Employer.

SPLICES FOR CONDUCTOR

The splices shall be of the compression type and shall consist of two parts, one of galvanized steel for the steel core and one of aluminum alloy for the aluminum part of the conductor.

All splices shall develop at least 95% of the ultimate strength of the conductor, according to BS 3288 part 2 or equivalent. The resistance of all splices shall not be more than 50% of the resistance of the conductor itself for the same length as the splice.

The splices shall be filled with grease to protect the conductor against corrosion.

All conductor splices shall be made no closer than 15m from suspension attachment point or 30m from dead end attachments.

JOINT BOXES FOR OPGW

OPGW joints shall be made using dead-end assemblies and the two ends of the OPGW shall be brought down the structure to a joint box.

The joint boxes shall be mounted at a height that prevents access by unauthorized persons, however allows access for maintenance purposes, while the transmission phase conductors are energized. The joint boxes shall be securely mounted and be weather tight in all projected conditions, including protection from vibrations.

Structure checks shall be completed to ensure the feasibility of mounting dead-end tension OPGW assemblies on suspension structures.

The Contractor shall follow the manufacturer’s guidelines for the jointing of OPGW.

REPAIR SLEEVES FOR CONDUCTOR

The repair sleeves shall be of the compression type for conductors and preformed armor rods for overhead ground wires. The compression repair sleeve shall preferably be two-piece type of aluminum alloy.

When properly applied, such repair sleeves shall achieve 95% of the ultimate strength of the conductor, when less than one fourth of the aluminum wires of the outer layer are damaged, according to BS 3288 part 2 or equivalent.

The resistance of the repair sleeves shall not be more than 50% of the resistance of the conductor itself on the same length as the repair sleeve.

The repair sleeves shall be filled with grease to protect the conductor against corrosion.

Repairs on overhead ground wires shall be made with preformed aluminum-clad steel armor rods.

TENSION CLAMPS FOR CONDUCTOR
The tension clamp shall be of the aluminum alloy compression type and equipped with an integral jumper lug. This lug shall have at least four bolt holes for connection of the non-tension compressor jumper end. The part in contact with the conductor shall be of aluminum.

The tension clamp shall be connected to the live end of the tension insulator set to ensure adequate flexibility.

When installed, the tension clamp shall develop a holding force of at least 95% of the ultimate strength of the conductor without causing slipping off, or damage to the conductor or any part thereof, according to BS 3282 Part 2 or equivalent.

Bolts shall be used as clamping devices only and not as current carrying parts. All bolts, nuts and washers shall be of high strength galvanized steel.

Tension clamps of the compression type shall consist of two parts, one aluminum compression body for the aluminum part of the conductor, together with an integral lug for connection of the jumper terminal, and one compression eye of galvanized steel for the steel core. The current carrying capacity shall be equal to or better than that of the conductor. The compression type of tension clamp shall be filled with grease after installation to protect the conductor against corrosion.

Tension clamps of the wedged or bolted type shall allow the conductor to run continuously through the clamp. No cutting off the conductor inside the clamp will be permitted.

OVERHEAD GROUND WIRE (OPGW) TENSION ASSEMBLY
OPGW Tension Assembly shall consist of hyper formed alum weld dead-end grip, associated hardware for earthwire attachment (shackle, link, clevis, and clamps), and flexible grounding loop connection.

Manufacturer’s guidelines for OPGW tension assembly arrangements shall be followed, subject to meeting the requirements of the following:

- The tension assembly shall be connected to the live end of the tension set to ensure adequate flexibility.

When installed, the tension assembly shall have a strength of at least 95% of the ultimate strength of the earthwire without causing slipping, or damage to the OPGW or any part thereof, according to BS 3282 Part 2 or equivalent. The current carrying capacity of any tension assembly shall be equal to or better than that of the ground wire.

JUMPERS

The jumper for tension towers with tension clamps of compression type shall consist of one un-spliced jumper conductor with one jumper terminal of the compression type in each end. The jumper terminal shall consist of an aluminum body together with an integral lug of four bolts for connection purposes. The jumper terminals shall be filled with grease to protect the conductor against corrosion. The resistance over the compressed tension clamp and the jumper terminal shall be less than 90% of the resistance of the conductor itself on the same length as the tension clamp and the jumper terminal.

Bolts shall be used as clamping devices only and not as current carrying parts. All bolts, nuts and washers shall be of high strength galvanized steel.

SUSPENSION CLAMPS

Suspension Clamps for Conductor

The suspension clamp shall be aluminum alloy, light and free to pivot in the vertical plane. The pivoting center shall be close to the conductor axis. The conductor groove shall be bell-mouthed at both ends. The groove shall be free of burrs and edges. It shall be tailored to suit the conductor for a turning angle of at least 25°.

Clamping pressure on the conductor shall not be applied near the ends of the supporting groove of the clamp where conductor-bending stresses are high. Clamping bolts shall be provided with locking devices.

The clamp design shall be such as permitting the installation of an additional device for the suspension of counter weights where required.

Armor rods shall be installed for the protection of the conductor.

Suspension Clamps Overhead Ground Wire (OPGW)

OPGW Suspension clamping arrangements shall comply with manufacturer’s requirements, subject to meeting the specification. The suspension assembly shall consist of armor grip suspension clamp (aluminum alloy hyper formed armor rods and suspension clamp), associated hardware for ground wire suspension, flexible grounding loop connection.

ARMOR RODS

Armor rods shall be of the factory pre-formed type and shall be made of material compatible to conductor, ground wire and installed in the suspension clamps. Rods shall be shaped in such way that they will grip the conductor and ground wire tightly.

The rod shall be capable of being installed by hand without special tools. The length of the armor rod shall be determined by the manufacturer of the vibration dampers.

Armor rods shall be of aluminum alloy for use on the phase conductors, and of aluminum clad steel for use on the overhead ground wires.

VIBRATION DAMPERS

Conductors and overhead ground wires shall be provided with vibration dampers of the Stockbridge type.

The damper clamp shall be of aluminum alloy. The conductor groove shall be smooth and free from irregularities. The damper clamp shall have sufficient grip to maintain the damper position on the conductor without damaging the conductor or causing premature fatigue damage on the conductor under the clamp. The dampers shall be designed for live line installation.

For duplex conductor, the spacer and the spacer dampers can be used to control the sub-conductor oscillation and maintain the spacing between sub-conductors. These must be installed at the spacing recommended by the manufacturers.

Additional dampers shall be installed at all angle and terminal towers, on all major crossing spans and on such other spans where, in the opinion of the Engineer, conductor vibrations are likely to occur.

The Contractor shall present damper application data provided by the damper manufacturer. The exact quantities of dampers required will be based on the application data.

Test reports showing the dynamic characteristics and the damping efficiency shall be submitted with the bid.

JUMPER COUNTER-WEIGHT
To reduce the swing and keep the clearance distances from the jumper to the tower, jumper counter-weights shall be used on the conductor.

The jumper counter-weight shall be made of hot dip galvanized cast iron and have an appropriate weight. The conductor-groove shall fit the conductor properly.

COUNTER-WEIGHT FOR SUSPENSION SETS
Counter-weights shall be attached by a U-bolt, acting on the conductor groove clamp at the pivot point.

The counter-weight shall be free to swing 45 degrees from the vertical plane.

1.3.4 Material Specifications, Towers

The members of latticed steel structures shall be of hot rolled steel angle sections. All tower material shall be factory made and entirely galvanized by the hot dip process.

1.3.4.1 Material

Material for the steel towers shall be of the type and grade most suitable for the application intended and shall conform to the latest applicable standard, specifications and recommended practices of the industry.

Mild steel and/or high strength steel shall be used for the fabrication of towers. The quality of steel to be used shall correspond to St. 37-3 and St. 52-3 according to DIN 17100 or equivalent. For tower bolts, reference shall be made to the relevant clauses hereinafter.

All material shall be tested at the factory in accordance with the applicable specification and standards under which they are manufactured. The Contractor shall supply the Employer with all certified mill tests if requested. Tests shall be conducted in accordance with ASTM/DIN Regulations or their equivalent. The tests to be conducted shall include, but are not limited to, uniformity of galvanizing coating, mechanical and chemical properties of all steel and additional embrittlement tests on high strength steel.

DESIGN STRESSES

The unit stresses in members and connections for the structural design calculation, based on the design loading and design unbalanced loading (broken wire conditions) multiplied by load factor indicated in the specification shall not exceed the yield stresses according to DIN or BS. Connections shall be designed for the same member forces and according to the above-mentioned standards. The towers shall be designed with an overload capacity factor of f1 times the unbalanced design loading stipulated in the Specification. No damage or permanent distortion of any members, bolts, connections of fittings or elongation of bolt holes shall be permitted for these design conditions.

The following slenderness ratios (L/R) of member shall not be exceeded, where "L" is the buckling length of member, and "R" is the corresponding radius of gyration of the members:

- Tower legs, main compression members in cross-arms & ground wire peak KL/R <150
- Other compression members carrying calculated stresses KL/R <200
- Redundant members KL/R <250
- Members subjected to tension only KL/R <400

For calculation of the buckling resistance of compression members, reference is made to the "Guide for Design of Steel Transmission Towers” (ASCE-Manual Nº 52) and to the ANSI/ASCE-Standard 10-90: “Design of Latticed Steel Transmission Structures”. Other approved calculation methods may be applied according to the Standards specified or otherwise approved by the Employer. In this case the calculated buckling resistance may not exceed the ASCE-level.

Towers shall be designed so that all members will withstand normal and broken wire conditions with load factors as specified.

The total loading for the tower shall include the dead weight of the tower plus transverse wind load on tower plus the simultaneous application of loading as specified above. Wind loads on tower leg extension shall be taken into consideration.

Terminal towers shall be designed to face the direction of the incoming line, and shall withstand the load of all conductors and ground wire.

The Contractor shall submit the stress analysis calculation for tower members of all tower types and for each of the specified load conditions. An explanation shall be submitted along with the computer calculation.

FULL SCALE TOWER LOAD TEST

Full scale tower load tests of assembled galvanized towers shall be carried out in accordance with IEC 60652 (latest version).

The following requirements shall be fulfilled in the load tests of the tower:

A. The members in a test tower shall be of the same grade and quality of fabrication as those to be supplied for the towers under these Tender Documents. The Contractor shall furnish certified test reports of the heats from which the material was rolled and a record showing the heat from which each member was obtained.

B. Test towers shall not be specially fitted other than with such fittings as are required on similar towers to be erected in the field.

C. Test towers shall be erected on a foundation structure which shall be of adequate strength and stiffness to safely withstand the tower reactions under test loading, without noticeable distortion or displacement. The tower legs shall be connected to the anchorage in the same manner as to the normal stub angle at site.

D. In preparing for the tests, the Contractor shall supply the Employer with a test program, together with diagrams indicating the proposed methods of applying the various loads and measuring of deflections. The Contractor shall calibrate dynamometers and gauges before testing the tower.

E. The test loads shall be those obtained from the design loads multiplied by the specified load factor. Any combination of the test loads shall be applied to prove the capability of the structure to withstand all required loading.

F. Each tower shall withstand the test loads for at least five minutes without failure or permanent distortion of any member, fitting, bolt or part and without elongation of bolt holes. There shall be no adjustment of loads during the five minute period. Should it become necessary to adjust the loading, the five minute period shall re-start after the adjustment is completed.

G. All test loads shall be removed completely before the loads for the next test are applied. Test loads corresponding to conductor and ground wire loadings shall be applied to the attachments provided for these loads while test loads equivalent to wind load on the tower shall be applied in locations approved by the Employer. Friction losses in rigging shall be taken into account in the application of the test loads.

H. Any conspicuous yielding or any failure under any of the test loadings shall be considered as a defect, in which case the Contractor shall modify the design and shall repeat, at his own expense, the test case in which a defect developed.

I. After all defects, developed during the regular tests, have been corrected and after the tower satisfactorily carries design loads multiplied by load factors, the tower shall then be tested to destruction.

J. Test samples shall be cut from members which fail in destruction tests and standard tensile tests shall be performed at the Contractor's expense. The results of the tests on these samples shall be used to correct the assembled tower test results for comparison with the design.

K. The Contractor shall submit full reports of all tower physical load tests including clear photographs of the test set-ups and nature of all failures, certified calibration reports, detailed diagrams showing the manner in which test loads were applied and deflection records.

L. The cost for the tower tests (supplying, erecting, testing and dismantling of towers, together with all rigging, accessories, dynamometers, gauges, and personnel necessary for the conduct of the tests, witnessing by the Employer, etc.) shall be borne by the Contractor.

M. Only one tower structure of its type (with maximum height extension) shall be tested. No member of such tower shall be used further in the execution of the Contract.

N. The tower structure shall be assembled with all step bolts/ladders in place. The Engineer will inspect all climbing provisions for strict adherence to the specification and suitability, by climbing every tower. Any modifications found advisable during this test shall be incorporated into the tower design, without any extra cost. Notwithstanding prior approval given for tower drawings, the design and location of all climbing provisions will be considered accepted only after Employer's confirmation in writing, of their suitability, after successfully climbing the test towers.

ACCEPTANCE OF EXISTING TEST REPORTS
In lieu of the above testing, certified results of a previous test may be acceptable, provided that the test results were adequately documented and test parameters were equal to or more demanding than the tests specified herein and that the towers tested were of the exact types tendered and specified for testing.

1.3.4.2 Construction

The towers shall be of standard construction and shall be designed to reduce the number of different parts to a minimum, thus facilitating transport and erection. No member shall be of dimensions less than 50mm x 50mm x 5mm. The minimum thickness for legs and compression members in cross-arms and in ground wire peaks shall be 6mm. Gusset plates shall not be less than 6mm thick.

Stub angles shall be at least 2mm thicker than the attached steel leg angle and shall be fitted with cleats. The stub angle shall be galvanized also below the top of the foundation concrete.

The maximum width of the steel leg angle shall not exceed 16 times the thickness. Cold formed steel angles, flat bars and rods shall not be used for tower members.

The diameter of bolt holes for all types of towers shall not be more than 1.5mm larger than the nominal diameter up to 16mm diameter bolts. For bolts above 16mm, the bolt hole shall be 2.00mm larger than the nominal diameter. All members of the towers shall be connected by bolts. Connections of members shall be designed to avoid eccentricity as much as possible.

1.3.4.3 Nuts and Bolts

Bolts shall have hexagonal heads and nuts, with metric thread (coarse) and shall conform to DIN 267 and DIN 555. In general, bolts for the connection of tower members shall not be less than 16mm in diameter. The minimum grade for bolts shall be 5.6 according to DIN 267.All nuts shall be secured by use of helical spring lock washers conforming to DIN 127 in connection with flat washers conforming to DIN 126.

All nuts and bolts shall be hot dip galvanized. Threads before galvanizing shall be a coarse thread. There shall be no excess of galvanizing at the root of the thread and nuts shall turn easily on the completed bolts without excessive looseness. Nut threads shall be tapped after galvanizing to produce a finger free fit on the galvanizing. Bolts will be rejected if they are considered by the Engineer to have an excessively loose or tight fit.

The length of bolts and the length of thread shall be such that bearing is upon the shank and not upon the threads. After tightening, the bolts shall project out of the nut a minimum of three threads.

1.3.4.4 Anti-climbing Devices, Step Bolts and Bird Guards

Each tower shall be fitted with an anti-climbing device to prevent unauthorized persons from climbing the tower. The anti-climbing device shall be fixed at a height of approximately 3 meters above the foundation. It shall provide suitable lockable gates adjacent to the step bolt legs.

The step bolts shall be provided on one tower leg only. They shall begin directly above the anti-climbing device and continue to the tower top. They shall be spaced at a distance of 300mm from center to center, distributed strictly alternating on the outer sides of the leg angle. The spacing distance of all step bolts shall be equal on the entire tower. Spacing tolerances according to VDE 0210/12.85 shall be accepted.

All step bolts shall be at least 24mm in diameter, with a free tread width of 200mm. For protection against slipping, a lateral limit of minimum 20mm above top of step shall be provided. The tread side of the step bolts shall be uniform for all towers. The fastening side may accommodate different sizes, to take advantage of holes provided for structural bolts. Step bolts shall be rated at least for a concentrated load of 1,500N, acting vertically at the most unfavorable position. If applied in place of a structural bolt, its loading shall be considered in addition to the step loading.

Tower members positioned above insulator strings shall be fitted with stainless steel needle strips, effectively preventing birds from sitting in these locations. The strips shall extend sufficiently, horizontally beyond the protected location and be applied to all surfaces a bird can sit on. Where needles are projecting from the cross-arm contours towards live parts, the tower clearance diagram shall consider the height of the needles.

1.3.4.5 Conductor and Ground Wire Attachments

Conductor and ground wire attachments shall be considered as part of the respective basic structures and shall be supplied as integral parts of them.

All conductor suspension points shall provide brackets for installation of suspension hinges suitable for the attachment of double and single insulator strings associated with suspension conductor support assemblies. Both, individual hinges and suspension point assemblies shall be orientated in line direction, allowing the insulator strings to swing in cross-arm direction.

Tension structures shall have brackets suitable for the attachment of tension hinges for double insulator strings associated with dead-end conductor assemblies.

The spacing of all double strings shall satisfy the requirements as specified under this Article below. Insulators of double strings shall be kept parallel at all line angles.

The ground wire shall be connected to the suspension structure peak by one hinge orientated in line direction, allowing the suspension assembly to swing in cross-arm direction. Connection to tension towers shall be provided by tension assemblies, to be fixed to the tower peak.

For direct connection of overhead ground wire shunts to the structures, 2 sets of two holes each, shall be provided on every ground wire peak.

1.3.4.6 Structure Grounding and Earth-Clamping Bolts

Each structure shall be provided with basic grounding and with additional grounding at tower locations with high soil resistivity. The ground electrodes may be either rods or pipes. Sections of the line may be placed in corrosive soil and the Contractor shall propose measures to protect the tower grounding from corrosion, subject to the approval of the Employer.

Types of ground electrodes and ground connections which can be used are indicated in tender drawings. For the connection of the copper conductor with the copper weld rod, the cad weld process shall be used.

For connecting additional grounding devices, sets of two holes each, are to be provided in all four stub angles to take two 16mm bolts.

As a service earthing point, one earthing bolt M 16, DIN 48088 part 2, to be delivered with spring washer, flat washer and nut shall be installed on the cross-arm steelworks, near to the base side of every insulator string in an easily accessible location, subject to the Employer's approval. This earthing point will be required for system earthing during line repair and maintenance work. The earth clamping bolt shall be designed to withstand the specified short circuit current for a period of 1 second.

1.3.4.7 Workmanship

All work shall be equal to 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. The Contractor 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. The fabrication shall be in strict accordance with the shop drawings prepared by the Contractor and approved by the Employer.

Structural material shall be straight and cleaned of all rust and dirt before being 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, sub-punched, reamed or drilled before galvanizing. Holes shall be drilled, not punched, if the thickness of the metal exceeds the diameter of the hole, and in all crossarm members exposed to permanent tension.

All holes shall be cylindrical and perpendicular to the member, clean cut with sharp tools and without torn or ragged edges.

Plugging, welding, or slotting of miss-punched, miss-reamed or miss-drilled 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.

1.3.4.8 Identification Plates

Table 1.3.6 Required Plates for Each Tower

Plate Type	Quantity / Tower
Danger signs	2
Tower number plate	1
Circuit number plates	1 Plate / Circuit
Phase plates	1 Set of 3 Plates / Circuit
Airborne observation number plate	Each Tension and every tenth Suspension Tower or as approved by Employer/Engineer

Danger plates shall feature red symbols on a white background. They shall comprise a skull with crossed bones, as well as lightning arrows conforming to DIN 40006. The text "DANGER" and line voltage shall be boldly written in both Dari and English languages.

Tower number plates shall show the tower number in black letters, on a white background. The height of the letters shall not be less than 150mm.

Circuit number plates shall show the circuit abbreviation and number in black letters, on a white background. Termination gantries shall be equipped with circuit plates showing the circuit names in full length.

Phase plates shall show the English letters "R", "Y", and "B", in black color, on red, yellow and blue background respectively.

The danger signs and the tower number plate shall be installed on the tower base at approximately 1.5m height. The number plate shall face the normal tower access. Fitting positions for all towers shall be submitted for Employer's approval.

The circuit designation, as well as the phase identification plates shall be installed under each circuit and shall be placed on the step bolt legs, directly above the anti-climbing device. They shall be positioned to reflect the phase allocation on the tower and to be easily identifiable from ground level.

Furthermore, on each tension and every tenth suspension tower an airborne observation number plate shall be provided. The tower number shall be cut from sheet metal, with a minimum letter height of 700mm. The plate background shall be black. The plates shall be installed, either on the top cross-arm or on the ground wire peak, in a position that is easily recognizable from the air. It shall be ensured that legibility of the cut-out number is not impaired by tower steelwork, placed behind the plate. Orientation of all plates on the line shall be uniform.

All plates shall be of corrosion resistant aluminum with embossed letters and painted, or of enameled steel. If enameled steel is used, great care has to be taken to ensure that the surface is completely enameled (including edges) and not damaged during transport and installation. In this case special washers of an approved material have to be provided for securing bolts and nuts without damaging the enamel.

On all plates, the colors shall be free from fading. Lettering and size of the plates shall be to the Employer's approval.

1.3.4.9 Marking, Packing and Handling

Each separate member of the tower shall be marked indicating tower type and number and the piece corresponding to the shop drawings. The marking for members that are used for more than one type of tower shall have all tower type designations.

These marks shall be embossed into the steel before galvanizing in such manner as to be plainly visible after galvanizing.

The marking shall be in the same relative location on all members, using different marks for different members, and the same marks for identical parts. Where high strength steel is used for any tower member, all of these members shall have distinguishing marks stamped on them adjacent to the identification number before galvanizing.

Tower members shall be assembled for shipment in bundles of the same size and weight containing pieces of the same or similar identifications mark and length. All bolts, nuts, washers, step bolts and minor fittings shall be shipped in wooden cases of suitable size and weight, with pieces properly separated according to size and type.

To ensure uninterrupted erection, the Contractor shall supply a 5% excess of bolts, nuts, washers, step bolts and minor fittings.

It is the Contractor's responsibility to ensure that the packing and handling is made in such a way that neither the steel nor the galvanizing shall be damaged in transit. Transport vehicles shall be clean and free from foreign material that in any way could injure the steel or zinc coatings.

1.3.4.10 Content of Drawings

Five (5) sets of hard copy and two sets of soft copy drawings shall be submitted for the Employer's review. These drawings shall show the following data and information for towers listed above and as shown on the conceptual design drawing:

- An outline drawing of the tower showing all basic design dimensions
- Electrical clearances in different angles
- Specified loading conditions
- Wind loads on the tower at each point of application

Stress diagrams or computer data so that the client can readily check the strength of the tower from the loading conditions specified.

A detail of the conductor, overhead ground wire and foundation attachments where not specified by the Engineer, including design calculations.

All shop drawings of towers and tower members and legs shall show the item assembled in place, clearly indicating all dimensions, the size, number and lengths of bolts required in each connection.

A bill of materials shall be prepared in tabulation form, listing all materials required for fabrication and assembly of the tower. The list shall show the number of items required and the total weight of each part.

1.3.5 Tower Foundations and Civil Works

1.3.5.1 General

The Contractor shall supply all materials, plant and labor and perform all operations required for the design and construction of all concrete foundation as shown on the drawings and other relevant civil works, as specified herein and as evidently necessary to complete the work.

Foundations shall be designed for all the specified tower types to produce an economical design. The designs, drawings and calculations shall be submitted by the Contractor for the review and approval of the Employer before commencement of the works.

The responsibility for proving the adequacy of the foundation type at each tower site shall rest with the Contractor. The necessary soil investigations including field or laboratory tests shall therefore be undertaken by the Contractor according to these specifications.

Parallel to these soil investigations, the Contractor shall also take water tests (analysis) in waterlogged locations to ensure the application of the correct cement type. The results of these tests shall be documented by the Contractor and submitted to the Employer.

Pile foundations or special foundation designs may be required in difficult locations or in exceptionally poor soil. The Contractor is required to design for each type of tower, suitable foundations, including pile foundations, if required, for each kind of soil encountered. Tower foundation designs for each tower type shall indicate geometry and volume of excavation and concrete and shall be submitted with the bid.

The Contractor shall be free to propose alternative types of foundations to those specified in the technical specifications, provided that these comply with all requirements specified. However, only the types specified shall be included in the main bid.

1.3.5.2 Design Data

The foundations shall be designed to resist uplift, overturning and vertical and horizontal pressure. Foundations shall also be able to withstand the stresses which may be imposed upon them under erection and stringing operations.

Ultimate loads derived from the structure design calculations shall be increased by 10% for application in the foundation design. Where unstable soil conditions exist, as well as lack of sufficient soil data, an increased load factor may cover uncertainties in the design.

Unless specified otherwise, design and details shall comply with the latest edition of BS or equivalent International Standard where such standards exist, with accepted national and international good practice.

In all locations, all steel work, whether part of the tower or part of the stub angle foundations shall be completely encased in concrete to ensure a cover of 100mm from any part of the stub leg or tower from a point 300mm above ground down to the base of the main foundation block. All stubs shall have cleats designed to carry the entire stub load.

Stub angle shall have galvanized steel and cross-sectional area of not less than the structure leg member to which it will be attached. The stub angle shall not be included in the calculation of the steel reinforcement requirements against bending and tension forces in concrete foundation design.

Stub setting templates, to the approval of Employer or Engineer, shall be provided by the Contractor. They shall be such design and construction as to resist distortion and damage and withstand repetitive use. They shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross-section and shall be equipped with central alignment notches or holes, corner braces, riser braces, and stub angles in respect of the following requirements:

- Route longitudinal center line
- Structure lateral center line
- Stub elevation (with reference to datum)
- Stub leveling
- Stub rake
- Stub hip bevels
- Stub angle spacing

No concrete installation shall be commenced before the stub setting is approved by the Employer or Employer's representative. After the completion of works all the templates sets shall be handed over to Employer. No extra payment for the design, manufacture and delivery for the templates shall be claimed by the Contractor.

The following unit weights shall be used in the foundation design for compression load and uplift and lateral loads:

Compression Load	
Soil:	1600kg/m^3
Concrete (PCC):	2400kg/m^3
Uplift and Lateral Loads	
Soil:	1200kg/m^3
Concrete:	1600kg/m^3

However, soil properties shall be determined finally from on-site soil investigations.

1.3.5.3 Calculations

The Contractor shall submit for all types of foundations detailed calculations showing that the ultimate earth bearing capacity is not exceeded by the maximum pressure due to loads, acting on the tower, multiplied with the corresponding load factor, and due to the dead weight of the tower and foundation.

The design shall further prove that the uplift forces on the foundation do not exceed the weight of the fictive anchor body in the soil, assumed to be in the shape of an inverted pyramid starting 25cm above the toe of the pile.

The Contractor shall also submit the Employer calculations and drawings showing the bearing capacity and stresses at each critical section of the concrete and the steel reinforcement.

The weight of non-reinforced concrete shall be assumed to be a minimum of 24kN/m^3 and that of reinforced concrete to be a minimum of 25kN/m^3.

Contractor shall nominate soil deflection limit design criteria.

1.3.5.4 Protection of Structure Foundations

At locations where earth movement (e.g., landslides, erosion, etc.) is likely to occur, the tower foundation and leg structures shall be protected against this effect by means of backfilling incorporating layers of stabilizing material/soil to prevent erosion, including the installation of surface water diversion channels around the tower bases.

Any approved stabilizing layer has to be well compacted and should have a thickness of not less than 500mm. The protected area must extend at least 5m beyond the edge of the foundations.

The Contractor shall suggest solutions for the foundation protection works where needed. The Employer will evaluate and give instructions for protection design. The Contractor shall design the protection work and submit his proposal for review and approval. The structure locations where such protection and type of protection are needed shall be finally decided by the Employer at site.

During site excavation works, where excavations (holes) are unattended by staff, the excavations shall be made safe, to protect people and animals, by placing covers over and/or temporary fences around the excavations.

The protection of tower foundations shall be as follows:

RANDOM RUBBLE 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 1:4 cement mortar after having joints thoroughly moistened. The surface joints shall be finished with 1:3 cement mortar. After completion of the masonry wall, it shall be cured with water.

Weep holes with perforated poly vinyl chloride (PVC) pipe of 100mm diameter shall be made in each $2m^2$ of slope surface of a masonry wall or as required by site conditions. The perforated pipe shall be extended at least 300mm both ends from the stone masonry wall and in the backfilling, the perforated pipe shall be covered with gravel at least 300mm around the pipe.

The unit price shall include supply of materials, construction, tools and plant, transport and placement of material to complete an effective installation, to the satisfaction of the Engineer.

STONE IN GALVANIZED WIRE NETTING INCLUDING EXCAVATION AND BACKFILLING (GABIONS)
The standard gabion shall be a flexible hot dip galvanized gabion of type and size specified below, made of wire mesh of type and size and selvedge as specified in the following:

The mesh shall be hexagonal woven mesh with the joints formed by twisting each pair of wires through three and half turns.

The size of mesh shall conform to the standard specification issued by the factory and shall not be greater than 1/3 of smallest stone filled in the gabion.

All wire used in fabrication of the gabions and in the wiring operations during construction shall be mild steel wire; i.e., wire having average tensile strength of $44kg/mm^2$.

The diameter of the wire used in the fabrication of netting shall be minimum 3mm and selvedge wire shall be minimum 3.9mm depending on the design requirement.

The standard gabion shall have following dimensions:

- Length: 2 meters
- Width: 1 meter
- Height: 1 meter

The unit price shall include supply of material, construction, tools and plant, transport and placement of material, to complete an effective installation, to the satisfaction of the Engineer.

PLAIN CEMENT CONCRETE (PCC)
The PCC shall be a concrete grade of M15 to cover the tops of the masonry and gabions. The minimum thickness shall be 100mm or as directed by the Engineer. The unit price shall include supply of material, construction, tools and plant, transport and placement of material, to complete an effective installation, to the satisfaction of the Engineer.

REINFORCED CEMENT CONCRETE (RCC)
The RCC shall have a minimum compressive strength of 21MPa for any foundation protection requirements. The unit price shall include supply of material (cement, reinforcement, sand, and aggregates), construction, tools and plant, transporting and placement of material, to complete an effective installation, to the satisfaction of the Engineer.

EXCAVATION WORKS
The excavation works cover the cutting of slopes, revetment works, and foundation structures for RCC and where sufficient ground clearances are not available. The price shall include proper disbursement of excavated soil. Payment shall be made per actual cut volume and the unit price shall include all labor, plant, material.

1.3.6 Grounding/Earthing

1.3.6.1 General

Every structure shall be permanently and effectively grounded to achieve a low footing resistance as per the drawings.

At structure sites in urban areas frequented by people, an additional protective earthing, i.e., measures for grading and controlling the ground step-potential during earth faults shall be carried out.

All cattle guards and buildings with metal sides or roofs, and other objects as decided by the Employer, which lie under or within falling the distance of the line, shall be earthed at two points in an approved manner. Details of the proposed method shall be included in the bid.

The Contractor shall carry out approved soil resistivity tests at each structure location to determine the number of rods or conductors required. The adopted method, drawings and test results of the soil resistivity shall be documented by the Contractor and submitted to the Employer/Engineer for review and approval.

1.3.6.2 Structure Footing Resistance

The footing resistance of any structure shall be less than 10 ohms. However, for the first 4 towers on either side of any substations, the maximum footing resistance shall be 5 ohms.

Individual structure earthing shall be made with earthing rods or when this is not possible, with radiating earth conductor (counterpoises).

1.3.6.3 Earthing Rods

Earthing rods shall be solid, copper-clad steel rods with a minimum diameter of 16mm with provision for coupling together with a suitable clamp for connection of the ground wire. The copper coating shall have a minimum thickness of 0.3mm.

1.3.6.4 Radiating Earth Conductors

Conductors for connecting structures to earthing, for radiating earth grid and for continuous counterpoise shall be copper-clad steel, according to ASTM B 228. Wires of the chosen conductor shall be at least 16mm.

The Contractor shall choose an appropriate conductor as above according to footing resistance and short circuit current.

1.3.6.5 Connections

The ground wire shall be directly connected to the tower with bolted connectors of an approved material suitable for use with the ground wire such that galvanic action, i.e., chemical reaction between copper and galvanized steel, is minimized.

Connections to the substations earthing grid shall be made by compressed clamps or bolted connectors of approved design.

1.3.7 Construction Specifications

1.3.7.1 Line Route Survey

GENERAL INFORMATION
The transmission line route is located as indicated on route maps included in Volume 2, Section 4.0. These maps are indicative only, for bid purposes. The Contractor is responsible for selection of best route considering construction, maintenance and cost aspects. The Contractor has to obtain final approval from Employer on the selected route before starting detail survey. The Contractor is responsible for final alignment, detailed survey, check survey, tower spotting, cross-section survey (side slopes) and leg extensions.

Before the Contractor commences work on any property, the Contractor shall obtain from the Employer a "Wayleave Schedule" which gives details of any special requirements of tenants or owners of the property concerned. The Contractor shall also be responsible for giving the occupiers of the land adequate notice of the commencement of the work, and shall inform the Employer at the earliest of any objections or hindrances encountered.

DE-MINING AND REMOVAL OF UNEXPLODED ORDINANCE (UXOS)
Mine clearance of the line corridor and access tracks shall be carried out by professional staff. The Contractor will be fully responsible for mine-related risks. A provisional sum for de-mining action shall be incorporated in the price schedule as an optional priced bid item.

De-mining and removal of UXOs shall be carried out by approved subcontractors employed by the main Contractor, specialized in such works and accredited by UNMACA (United Nations Mine Action Center for Afghanistan).

The Contractor shall assume total and complete responsibility for the scheduling of personnel and plant into areas required to be de-mined. All areas required for traffic diversions or bypasses shall be specifically established and de-mined. The Contractor shall, as his first priority, assign a senior member of his organization to meet and coordinate with UNMACA on all requirements for the removal of land mines and unexploded ordnance. UNMACA will act as quality assurance agent.

The Contractor shall separately submit a program for de-mining works, and this shall be incorporated in the overall program of works. No personnel or plant shall be permitted in any area until the area has been certified to be free from mines and UXOs.

LAND ACQUISITION AND RESETTLEMENT PLAN (LARP):
The Contractor shall be fully responsible to select the transmission line route considering the environmental and socio-economic aspects. As far as possible, the transmission line route is to be selected in Government land, uncultivated land, non-habitation areas, and away from urban areas in liaison with local Authorities, the Employer, landholders and other interested parties. The environmental and resettlement aspect will be the responsibility of the Employer, however the Contractor shall work closely with the Employer to provide and collect necessary information/data as required.

The Contractor shall avoid or minimize damage to crops and detrimental environmental impacts during the construction work. Any damage is the responsibility of the Contractor, in regard to rectification work and compensation payments. Such costs are deemed included in the Contract Price.

Following are minimum requirements to support the Land Acquisition and Resettlement Plan (LARP):

- Transmission Line route to be selected in an effective and professional way, so that issues of LARP may be avoided or minimized. If required as a solution, an alternative route diversion may be surveyed.
- Minimization of damages to crops, cutting trees etc.
- Minimize effects of heavy plant during the construction to avoid impacts on houses and infrastructure.
- Consultation to be conducted with local government authorities and local affected people before any works to be commenced.
- Access roads for construction purposes to be made as early stage, to minimize environmental impact.
- Before any works to be performed, consider and minimize effects on environment, social impact and people.

CLEARING OF THE LINE ROUTE
The Contractor shall perform clearing of the line route. The clearing will consist of the removal and disposal of trees and other vegetation, houses and huts, barns, cattle-sheds, etc., within a total width of 35m; i.e., 17.5m on each side of the center of the transmission line. All tall trees, which after falling may be within 20m of the transmission line center, shall be removed even if outside the 35m cleared right-of-way. All trees which would cause flashover from a conductor if deflected up to 75° from the vertical shall be removed. In determining the flashover clearance and in estimation the mean height of trees, due allowance shall be made for seasonal growth.

No clearing of the line route shall take place until compensation and other entitlements have been made to the affected persons.

1.3.7.2 Route Survey

LINE PROFILE SURVEY
The topographical line survey shall be carried out along the approved line route.

The theodolites used and measuring techniques applied shall be state of the art, employing digital recording techniques, to the Employer's satisfaction. The survey shall be carried out to a minimum accuracy of 1 in 2,000 for distance.

The Contractor shall prepare longitudinal profile drawings of the transmission line, in scales of:

- Horizontal Axis 1: 2,000
- Vertical Axis 1: 200

The profile drawing shall contain the longitudinal ground profile along the line centerline, plus side profiles right and left under the outermost conductors, shown as different dotted lines on the plans. They shall display the bottom conductor catenary, at 75°C, together with the ground or special clearance curves, as well as the minimum temperature catenary. Tower numbers, tower types, weight spans, wind spans, equivalent spans, section lengths, continuous chainage, elevations, level differences, UTM (Universal Transverse Mercator) coordinates, shall be shown.

Along the footer of the profile drawing, a strip plan of the line route, extending 35m beyond either side of the centerline, shall be shown. The strip plan shall detail all relevant information regarding obstructions, services, vegetation, trees, terrain type, land use, land ownership boundaries, together with the names of the land owners. The names of the Employer's and local representatives who participated in the survey shall be detailed on the strip plan. Horizontal and vertical coordinates of all features affecting the line construction shall be indicated on the profile plan. Crossings of existing overhead lines shall be documented with measured elevations and locations of their top and bottom conductors, at centerline and side profile limits, together with the air temperature at the time of measurement. All crossings shall be covered by individual clearance calculations, to be shown on the profile plan. Tower center coordinates and all elevations shall be reduced to UTM (Universal Transverse Mercator) datum, and indicated on the profile plans.

The Contractor shall locate and indicate benchmarks and reference points already existing in the project area. The Employer will assist the Contractor in providing information about locations of the reference points. Where these do not exist, the Contractor shall provide such reference points in consultation with the Municipalities.

The line route shall be marked in the field by timber survey pegs of 800mm length, with a cross section of minimum 50mm x 50mm to be driven flush into the ground. The accurate centerline shall be shown on the pegs by a single nail, to be driven into the peg top. Terminal and angle pegs shall be secured by a concrete foundation, to the Employer's approval. Straight line concrete pegs shall be driven along the line centerline, at a minimum of 4 per km, and to either side of every line crossing. After approval of the tower locations on the profile plans, tower center pegs shall be driven at site. After final approval of tower locations, which will be given by the Employer after detailed site inspection, insurance pegs shall be driven, approximately 30m to either side of each tower center peg, in line direction. Different kinds of pegs shall be distinguishable by a paint color marking system, to be submitted for the Employer's approval.

All pegs or other marks shall be preserved until their removal is authorized by the Employer.

For the purpose of profile/tower-location inspection by the Employer, all terminals, angle, and other relevant line points shall be marked by red flags with a minimum size of 1.5m x 1.5m, to be mounted on minimum 5m high poles.

The Contractor shall minimize the number of tower locations between line angle points, without exceeding the tower/conductor design limits. The tower distribution shall be performed by means of a recognized computerized optimization program, to Employer's approval and will be independently checked by the Engineer.

To facilitate approval of profile plans, the Contractor shall provide the Employer with two complete sets of transparent sag templates in Perspex or similar material, 4mm to 5mm thick, based on the range of equivalent spans required, staggered at 50m, and for the conductor types and scales to be used. The templates shall be cut precisely along the conductor catenary in still air, at maximum temperature (hot curve at 75°C). The sag curve in still air, at minimum temperature (cold curve at -5°C), the span grid, the ground clearance line, and all relevant details such as design loading conditions, particulars of conductors, equivalent span applicable, scales, etc. shall be engraved on the templates.

CROSS-SECTION SURVEY FOR TOWER LOCATIONS

After approval of profile plans with tower distribution, the Contractor shall prepare diagonal cross-sections of all tower locations, to determine leg extensions/reductions, foundation platform/protection requirements, and foundation setting levels. It shall be ensured that the foundation concrete caps will have a minimum height of 0.75m above final ground level.

Angle and terminal towers shall be placed within survey accuracy limits (see above). Straight line towers shall be located and centered within 100mm of the center line transversely, and within a 0.5% deviation of their back span length longitudinally, relative to their specified position on the profile plan.

Relocation of a tower exceeding the longitudinal deviation limit will be allowed only if approved by the Employer and for purposes of improving soil conditions for foundation work or for avoiding houses. Such relocation shall in any case not exceed more than 10m in either direction and will be allowed, provided ground clearance is not impaired and specific loading of the particular tower is not exceeded.

Towers in tangent positions shall be oriented with the transverse faces at right angles to the transmission line center line, and towers in angle positions shall be oriented with the transverse face at right angles to the bisector of the deviation angle. Towers with asymmetrical cross-arms shall be offset from the theoretical centerline, to equalize the distance between conductors on each side of the tower from the theoretical centerline.

RIGHT-OF-WAY AND CLEARANCE
The Employer is responsible to obtain the Right-of-Way (RoW) along the transmission line corridor, but the Contractor shall be responsible for surveying, marking and clearing the Right-of-Way (RoW). The Employer is responsible for any cost related to the obtaining of RoW.

The Contractor shall make the necessary arrangements with property owners so as to permit cutting or trimming of trees located both inside and outside the right-of-way, where such cutting or trimming is unavoidable. The Employer may extend assistance to the extent possible.

In addition, where trees outside the cleared area have such a height that they could fall within 2 meters of the conductors, they shall be cut or trimmed to such a height to avoid such a possibility.

Any cost arising from any removal of vegetation will not be remunerated separately, it is deemed to be included in the Contract Price.

ACCESS
The Contractor shall provide and maintain all access to the transmission line route and the tower locations, as required for his construction work (Survey, Foundation, Erection, Stringing etc.). If the access is not available on planned location and interrupted due to the unseen reason, Contractor has to shift (mobilize/demobilize) his team where the access is available.

The Contractor will not be reimbursed for waiting time, mobilization and demobilization caused by delay in right of way and access.

The Contractor shall reinstate all access to the transmission line route, after construction, to normal condition. All surveys, drawings and scope of work for access provisions intended by the Contractor shall be submitted, prior to construction, for the Employer's approval.

Any cost arising from access shall be made to the Contractor on account of obtaining Right of Way, access, maintaining or repairing these access roads up to Taking-Over. The same applies to slight changes on the line routings such as may be required in shifting the transmission line route due to the requirements of local Authorities and the Employer.

1.3.7.3 Soil Investigations

SCOPE
The scope of work covers all the work required for geotechnical investigations and preparation of a detailed report. The work shall include mobilization of necessary plant, providing necessary engineering supervisors and technical personnel, skilled and unskilled labor and others as required, to carry out field investigations and tests, laboratory tests and analysis and interpretation of data and results, preparation of a detailed soil report including recommendations and providing technical services as when called for by the Employer. The investigation method shall be as described herein or any other methods approved by Employer giving the same information as needed to ensure that soil parameters are sufficient for reliable foundation design. The location for

geo-technical investigations shall be approved by the Employer. The Contractor shall submit the method statement for soil investigation field work and laboratory testing methods.

CODES AND STANDARDS
All work shall be carried out strictly in accordance with the Technical Specifications unless otherwise approved by the Employer in writing. Where not specified, the latest edition of one or more of the following codes of practice or any other applicable code shall be followed.

Table 1.3.7 Soil Investigation - Applicable Codes and Standards

Soil Investigation - Applicable Codes and Standards	
BS 1377	Methods of Test for Soils for Civil Engineering Purposes
BS 1924	Methods of Test for Stabilized Soils
BS 5930	Code of Practice for Site Investigations
BS 6031	Code of Practice for Earthworks
BS 2004	Code of Price for Foundations

Codes equivalent to these in American/DIN Standards may also be used.

CALIBRATION OF PLANT
The Contractor shall ensure that all the plant/instruments are properly calibrated and approved laboratory test certificates shall be submitted to the Employer. If the Employer desires to witness such tests, the Contractor shall arrange for the same at his own cost.

SOIL INVESTIGATION WORK
It is essential that personnel on this work of geotechnical investigation and laboratory testing should have the appropriate experience. The entire investigations shall be supervised by a suitably qualified and experienced engineer or engineering geologist. All the specified locations for boreholes and field tests shall be set out at site by the Contractor. The Contractor shall perform the minimum following activities during the field investigation work:

METHOD OF BORING AND SAMPLING
In soil strata, boring may be carried out by auger or percussion tools or by methods approved by the Employer or Engineer. The diameter of the boreholes unless stated otherwise shall be such as to permit collection of undisturbed samples of 90mm diameter. Where necessary, boreholes shall be cased and whenever a borehole is cased, the bottom of the casing shall always be maintained within 150mm of the bottom of the borehole. The casing shall never be in advance of the bottom of borehole during undisturbed sampling or standard penetration tests. All the boreholes shall be sunk to a depth of 6m in field.

The general sequence of sampling adopted shall be such as to obtain alternatively undisturbed samples at every 1.5m intervals and at every significant change of stratum. Likewise disturbed samples, as obtained in the standard split spoon shall be collected by conducting the standard penetration test at every 3m interval and a significant change of soil stratum.

Standard penetration tests shall be carried out at 1m intervals and at every noticeable change of soil formation and as per the BS or ANSI Standard. The test shall be done 6m to 20m depth. The test shall be stopped when the total blow count including seating drive reaches 120 and the corresponding penetration shall be noted.

The Contractor shall take about one liter water sample from the bore hole and store in an air tight bottle. Water samples shall be tested as soon as possible after collection.

The Contractor shall assign a reference number with appropriate labeling to each soil and water sample taken from the bore hole as per order of depth and samples shall be transported safely as soon as possible.

The specific observations to be made during boring are the sequence and thickness of different strata, ground water table, loss or make of drilling fluid, presence of lime, mica etc. and completion of field logs.

LABORATORY TESTS
Laboratory tests shall be performed by qualified and experience personnel. The testing laboratory shall be approved before commencement of the testing works by the Engineer.

The test report recommendations shall include but not be limited to the following:

- A brief geological description including faults, folds, etc. on the basis of published literature
- Seismic history including a brief description of previous earthquakes, giving time, period, magnitude, ground acceleration, epicenter, damage done
- Recommended type of foundation and safe/allowable bearing capacities
- Possibility and extent of scour in river beds
- Recommendation of class of concrete to be used for foundation and vis-a-vis deleterious effect of ground water/soil chemicals concrete steel
- Recommendation of type of cement to use
- Earth pressure coefficient that may be adopted
- Any other relevant information and data
- Technical services as and when requested by the Employer

All costs related to the soil investigations will be paid at the unit price bid. Therefore in the price schedule, the unit price shall include full compensation for all costs incurred in furnishing all materials, labor, plant, technical services, testing, reporting.

1.3.7.4 Measurement of Ground Resistance

The Contractor is required to perform ground resistance tests at every support location. Method of measurement, tools and instruments shall be submitted to the Employer/Engineer for approval.

The Contractor shall recommend the type of earth electrodes in accordance with the result of ground resistance data obtained. The data shall be prepared in an approved form and submitted to the Employer.

1.3.7.5 Erection of Structures

LOCATION OF STRUCTURES
Unless otherwise specified, straight line structures (suspension) shall be installed to have the cross-arm at right angles to the line direction, and angle structures to have the cross-arm bisecting the line deviation angle.

Tolerances of centers of suspension tower location shall be as follows:

- In span length 1m- 2m
- In height 0.5m

Deviation from a straight line between two adjacent structures shall not be allowed.

ERECTION WORKS

General
The Contractor shall ascertain that all concrete foundations or rock anchor grouting are cured and that all backfill is compacted to its approved level before placing or erecting tower steel on the foundations. Concrete in tower foundations shall be allowed to set a minimum of 14 days before erection of the tower and a minimum of 28 days before conductor and ground wire installation on the tower.

The Contractor shall erect the types of towers specified at the locations indicated on the Contract Drawings.

Structures shall be assembled in accordance with the approved drawings and erected by a suitable method which will not overstrain structural members or their foundations, subject to Employer's approval.

Handling And Storage
Steel shall be stored on wooden supports of sufficient height to avoid any ground contact or other contamination. Storage conditions shall be well ventilated, preventing the formation of wet storage stain from accumulation of humidity and sand. It shall be clearly understood, that white rust formation will lead to rejection of the affected material.

All necessary measures shall be taken to prevent structural injury to members, or damage to galvanized coatings. Members shall not be dragged on the ground or will the practice of throwing tower steel into piles on conveyances, or from conveyances onto the ground, and of skidding steel members over each other, be permitted. Lifting of tower steel shall not be done with steel slings, being in direct contact with galvanized surfaces. Instead, fabric belts, or other suitable protection shall be used.

Damaged tower material shall be replaced by the Contractor at no cost to the Employer.

Small accidental damage to galvanized surfaces may be repaired by application of approved zinc repair paint. Larger areas of damage to or systematic defects of the galvanizing shall be repaired by hot-dip galvanizing only.

The attempt to repair shall not bind the Employer to accept the repaired part when this is re-offered for inspection.

Acceptance by the Employer of any repaired galvanized steel does not absolve the Contractor from his responsibility of supplying galvanized steel to give satisfactory service in the prevailing corrosive atmosphere. The Employer reserves the right to reject any galvanized steel found rusty, damaged, bent or otherwise defective, before final acceptance.

Stub Angles
Stub angles shall be set carefully in excavations prepared for them and maintained within the following maximum tolerances:

- Stub angles shall be located horizontally so that each is within 1/1000 of the distance, between the center and any stub angle. Two stub angles of one structure shall not differ horizontally by more than 1/1000 of the sum of the distances identified in the tower design

- Difference in elevation between identical parts of any two stub angles shall not exceed 1/1000 of the horizontal distance between stubs, allowance being made for the difference, if any, in leg extension lengths.
- Face batter of the stub angles shall not differ from the design by more than 5.2mm per meter of exposed stub.
- Twist ± 1.6mm measured from the edge of the stub angle to a line connecting the corners of diagonally opposed legs.
- The actual elevation of any set of stub angles shall be within 60mm of the specified elevation.

Erection
During the erection, no tools shall be taken up the towers, except structure torsion wrenches and drift pins. Only such wrenches will be allowed, which do neither deform nor injure the galvanized coating of the bolts/nuts. Use of drift pins is limited to guiding the different tower members into position, without enlarging holes or distorting tower members.

Each bolt shall be securely tightened with adequate but non-excessive torque. Proper tightness shall be spot checked by the Contractor, to the Employer's satisfaction, with an accurately calibrated torque wrench. The Contractor shall indicate the torque that shall be applied for each bolt size. All tower bolts shall be completely tightened, immediately after a tower is erected. After erection, towers shall be left in workmanlike condition, complete and safe in every respect.

Throughout tower erection, the Contractor shall ensure that un-braced members are adequately supported by stays or guys or temporary struts, prior to being braced. The bracing of all four sides of the tower shall be completed before removal of guys or temporary struts.

In order to prevent pilfering, all bolts and nuts below a minimum height of 3m above the foundation cap shall be secured by suitable means, to be proposed by the Contractor, for Employer's approval.

A reasonable amount of drifting will be allowed in assembly of towers. Any drifting used shall not distort the metal or enlarge the hole. Accidentally missing/mismatched holes may be drilled/reamed at site, only in exceptional cases, subject to the Employer's prior approval and a proper application of repair paint. Reaming/drilling at site, for correction of mismatched/missing holes due to systematic shop errors, will not be tolerated. Members so affected shall either be hot-dip re-galvanized, after repair, or entirely replaced with correct material.

Earth clamping bolts and tower sign plates shall be installed according to the articles above.

Towers must be completely erected with all members in place and bolts securely tightened and checked for tightening torque before any stringing of conductors or ground wires may commence. All towers shall be inspected by the Employer accompanied by the Contractor before the stringing operation. Prior to the erection of towers or parts of towers, which have been completely assembled on the ground, the approval of the Employer is required.

After conductors and ground wire have been installed and sagged, all towers shall stand plumb, with a tolerance on vertical deviation not exceeding 3mm/m.

1.3.7.6 Foundations

EXCAVATION AND BACKFILLING
Except when stated below, towers shall be placed on undisturbed soil.

Excavations shall be kept dry during installation of foundations. Whenever necessary or as required by the Employer, the Contractor shall re-excavate loose materials which have accumulated in previously prepared pits.

No additional payment will be made for blasting, sheet piling or water pumping. Excavated soil may be used as backfill if it is suitable for compacting. Rock and soil not suitable for compacting shall at the Contractor's own cost, be removed and replaced with a suitable backfill material, to the satisfaction of the Employer.

All filling material shall be free from cinders, ashes, refuse, vegetation or organic material, boulders and other material, which in the opinion of the Employer is unsuitable.

Backfill shall be placed in layers of approximately 200mm thickness until the weight of soil = $1.6t/m^3$ and certificates of works shall be prepared. Each layer shall be carefully compacted by means of suitable pneumatic or equivalent tampers.

Backfilling shall be carried out to a minimum height of 200mm over the original ground surface to compensate for the future settlement of the filling.

All backfilling of tower foundations shall be protected from being washed away by surface water in an approved manner. At all tower positions, the surface of the ground shall be sloping from the tower foundations to provide drainage as required. No additional payment will be made for such work.

At certain places, additional protection against erosion may be required such as installation of rip rap or ditches. Any such work, when decided in agreement with and authorized by the Employer will be paid for based on prices in the schedule of rates and prices in the contract.

TYPE AND SIZE OF FOUNDATIONS

The Contractor shall be responsible, at his own cost for ascertaining that the foundations to be employed are suitable for the sub-soils encountered at each tower site. For this purpose and at his own cost the Contractor will be responsible for classifying the sub-soils at each tower site at an early stage of the Contract. The type and number of soil tests to be carried out in order to determine soil conditions, reports and materials shall be to the approval of the Employer.

The soil tests shall be carried out at tower sites located near streams and rivers or places where it is not likely that rock will be found. Towers near exposed rock shall normally not be tested.

The Contractor shall be responsible for any subsidence or failure due, in the opinion of the Employer, to insufficient care having been taken in his examination of ground conditions or in erection of the towers.

The results of the soil tests (reports and materials) shall be submitted to the Employer in an approved manner together with proposals for each tower site for use of a class of standard foundation as given under Specification of Foundations or the need for a special or modified standard foundation design. The class of foundation proposed for each tower site shall be approved by the Employer before commencement of foundation work.

A record shall be kept of each tower installed including details of the strata of the ground throughout the depth of excavation, the presence or absence of water during construction, physical-mechanical characteristics of soil, classification of soil as per difficulties in excavation, and liability to seasonal flooding, together with results of tests carried out and all other relevant information.

HYDRO-TECHNICAL CHARACTERISTICS OF AREA

Following survey results, the Contractor has to show on plan and profile drawings, the line route sections where the crossings of irrigation and collector arrays, with width and depth, disposals, disposal areas, bank height, wash-outs of banks, ravines.

CLIMATIC CHARACTERISTICS

General characteristic of area:

- The Contractor shall show the profile of the line route, to indicate altitude marks, air temperature, dryness, fog, annual precipitation, and ice and wind parameters.

- Wind mode: The Contractor shall assess the flow, circulation, direction of synoptic process (storm “afganec”), maximum annual wind speed and design speed of wind.

- Ice-slick mode: The Contractor shall study types of deposits, periods and assess the level of ice-slick load.

- Atmospheric temperature: The Contractor shall assess and submit assessments of temperatures. Determine the average monthly and annual temperature, experimental air temperature, design air temperature.

- Precipitation mode: The Contractor shall assess the average annual rainfall.

- Snow, frost zone: The Contractor shall assess the average number of frost days. A frost zone of ground occurs when temperature is at or below 0°C.

- Lightning: The Contractor shall determine the average duration of lightning periods; lightning days/year.

EARTH AND ROCK WORK GENERAL

The Contractor is responsible for all necessary safety measures and shall be liable for any damage and accidents occurring while earthwork is being excavated and removed. Proper bracing, including any necessary re-arrangements to protect slopes or cribbing, preparation of design calculations, shall be deemed included in the Contract Price.

In the event soil slides occur during earth and rockwork, all damage will be to the Contractor's cost. No payments will be made for the additional moving of soil resulting from such damage.

Clearing and Grading

The sites of all tower base work shall be cleared and leveled so that on completion of the work, the finished reinstated ground level shall normally be at least the same as prior to commencement of the work.

Backfilling

Refilling of foundations shall be carried out only after all works within the excavations have been inspected and approved by the Employer. Unless otherwise directed, all filling shall be approved selected material, and shall be deposited and compacted in layers not exceeding 150mm thick for hand compaction and 200mm for mechanical compaction, loose depth.

During the placing of backfill material, the hole shall be kept free from water. All temporary timbering and all decomposable material shall be removed from the excavations prior to backfilling.

Settlement

The Contractor shall be responsible for making well all settlement of filling due to any cause whatever which may occur up to the completion of the maintenance period.

SURPLUS MATERIAL
All material surpluses to the requirement of fill, and all debris and rubbish shall be removed and deposited as directed by the Employer.

ROCK ANCHORS
Drilling in Rock
All drilling operations shall be carried out by qualified personnel, using only approved methods and plant. Flushing with water when drilling shall be employed whenever possible.

Drilling mud and lubricants on drill rods shall be used only where permitted by the Employer.

The drilling of holes in rock for anchors, drainage and grouting may be carried out by means of percussion rock drilling machines. The diameter of holes for anchors shall be 1.5 to 2 times the diameter of the steel bar.

When holes are completed, they shall be temporarily plugged until they are used for their purpose.

The drilling of drain holes in rock shall be carried out in the vicinity of holes where grouting is going on, and restrictions specified by the Employer in this respect shall be adhered to.

Anchors
Anchor bolts shall be used for anchoring concrete structures to rock. Strengthening of the rock may be effected by means of grouted-in bolts.

Anchors in rock shall be of a quality approved by the Employer. They shall consist of deformed steel bars meeting the requirements of type "High Yield" according to BS 4449 or equivalent and shall normally have a diameter of 25mm. The bars shall be thoroughly cleaned before they are placed in position.

Anchors in rock shall be grouted-in either by the Perfo method or the SN method. The Perfo method involves the two halves of a perforated steel tube of the same length as the hole first to be filled with a stiff sand-cement mortar. The halves shall then be put together and inserted right to the bottom of the drill hole.

Immediately afterward, the bar shall be driven into the tube by means of a pneumatic hammer so that the mortar, pressed through the perforations of the tube, completely fills the space between the bar and the rock.

According to the SN method, the holes shall firstly be filled with mortar through a hose inserted to the bottom of the hole and successively pulled out as the mortar fills the hole. The bar is then driven into the hole by means of a pneumatic hammer. When specified on the drawings, the steel shall be of a weldable quality approved by the Employer.

The holes shall be thoroughly cleaned with water and air immediately before they are filled with mortar.

The grout may either be cement grout or sand-cement mortar. The consistency and composition thereof shall be approved by the Employer.

Where shown on the drawings or as directed by the Employer, the protruding ends of the bars shall be bent.

Where directed by the Employer, testing of the anchorages shall be carried out. The protruding ends of the bars shall then be given a sufficient length from the surface of the rock to allow the fixing of a hydraulic jack provided by the Contractor. The matrix of the jack shall be designed to ensure a satisfactory grip up to stresses of 300N/mm2 in the bar. When the number of failures is five per cent or less, not more than five per cent of the total number of anchorages will be tested as prescribed above.

DEWATERING
All excavations shall be kept free of water. Surface grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by the Employer or Engineer any water inclusive of rain water and subsoil water accumulated in the excavation and keep all excavation /trenches free of water when required for further work.

Method of pumping and a method statement shall be approved by the Employer. In any case the pumping arrangement shall be such that no movement of soil or in-flow shall occur, due to a differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

No separate payment will be made to the Contractor for dewatering of tower foundations. All costs related to dewatering shall be included in the unit bid price for the construction of foundation work.

SHORING WORKS
This covers the general requirements of timber or steel shoring for open excavation for structure foundations. Shoring may be required to keep the sides of the excavations vertical to ensure safety of staff, of adjoining structures, or to limit the slope of excavations, or due to space restrictions or for other reasons.
The Contractor shall submit the design calculations, drawings and method statement for shoring works for review and approval of Employer/Engineer.

All costs related to shoring works shall be included in the unit bid price for the construction of foundation work.

1.3.7.7 Installation of Insulators, Conductors and Overhead Ground Wire (OPGW)

INSULATORS (SYNTHETIC AND/OR DISC TYPES (WHERE APPLICABLE))
Insulators shall be handled with the utmost care in order to avoid chipping or cracking of the discs or damage to the polymer housing, and bending of the pins. Insulators shall remain in their shipping crates until required for assembly at the cross-arm.

Before assembly, all units shall be closely inspected. Bent pins will not be allowed. In order to minimize the risk of pin bending, no rope slings shall be used for lifting assembled units, but a suitable hook shall be applied to the insulator.

Before installation and immediately before hanging, the insulator shall be thoroughly cleaned, and all cotter pins shall be checked for correct positioning and freedom from defects.

Insulator strings may not be climbed; a ladder must be used.

All bolts, nuts and cotter pins shall be installed to facilitate easy inspection and live line maintenance work.

Prior to energizing the transmission line, the Contractor shall ascertain that the surfaces of the insulators are clean.

CONDUCTOR JOINTS AND TENSION ASSEMBLIES
Compression joints and tension clamps shall be installed according to good engineering practice. The Contractor shall submit a method statement for the complete installation procedure, for the approval of the Employer.

The person appointed by the Contractor to be responsible for the installation of the joints and tension assemblies shall punch his identification sign on each assembly. All installations of joints and clamps shall be made in the presence of the Employer and shall be punched with his identification sign.

Wherever possible, full use shall be made of maximum drum lengths of conductors and overhead ground wires in order to reduce the number of joints.

The number of joints and their locations in the spans shall be approved by the Employer. No joints shall be made in spans which cross main roads, power lines or major river crossings, or whenever conductor drum lengths permit, in spans immediately adjacent thereto.

There shall not be more than one joint per conductor in any one span, and tension joints shall not be closer than 30m to the center of suspension clamps and 100m to tension clamps.

The Contractor shall keep a record of all joints and tension clamps, indicating the location, type and date of each assembly.

OVERHEAD GROUND WIRE JOINTS AND TENSION ASSEMBLIES
Overhead ground wire joints and tension clamps shall also be made according to the requirements of the previous clause where applicable. The procedure to be followed shall be as recommended by the manufacturer, and will ensure the OPGW fibers are not damaged and provide reliable communications over the life of the cable.

REPAIR SLEEVES
In case of damage to the conductor aluminum strand, an approved repair sleeve shall be installed provided the damage consists of not more than one fourth of the strands in the center layer being broken, or dented deeper than one half of their diameter. When more than one fourth of the strands are damaged, the damaged section of the conductor shall be cut out.

Conductor repair sleeves shall not be installed without written permission of the Employer/Engineer. Repair sleeves shall be installed in the presence of the Employer. The Contractor shall keep a record of all repair sleeves indicating the locations, type and date of each assembly.

STRINGING PULLEYS
Stringing pulleys shall have adequate strength and shall be of approved design. They shall be equipped with ball or roller bearings. The sheave diameter measured at the bottom of the groove shall not be less than 20 times the outside diameter of the conductor or overhead ground wire and shall be fabricated from aluminum, with a neoprene rubber liner.

The groove shall be wide enough for the passage of compression joints. Stringing pulleys for the conductors and overhead ground wires shall have the sheave grooves lined with electrically conductive neoprene or equivalent. Pulleys shall be inspected daily for proper operation. The use of defective pulleys will not be permitted.

STRINGING

Conductors and overhead ground wires shall be pulled out and strung by an approved tension stringing method. Conductors shall, as a principle, never be allowed to touch the ground.

The Contractor shall submit in writing, for the approval of the Employer, a complete and detailed description of the stringing plant and the stringing and sagging procedures intended for use.

Unless otherwise approved by the Employer, the tension stringing procedure shall be in strict conformity with the recommendations of the manufacturer of the stringing plant. Only specially trained linesmen must be employed who are well acquainted with the handling and running of the particular plant to be used.

Reliable means of instantaneous two-way communication must be available between the pulling and the braking crews, and between these crews and any observation posts that may be placed along the stringing section.

The stringing plant shall be set up so as not to cause excessive vertical loads on the towers/cross-arms. The distance to the nearest tower through which the cables are being strung shall be selected with due regard to the relative levels of the pulleys on the tower and the stringing plant, with reasonable allowance made for possible accidental over-tensioning of the cables. Stringing pulleys shall preferably be located at approximately the same levels as that which the conductors and overhead ground wires will occupy when installed.

At all times during stringing, the conductors and overhead ground wires shall be handled and protected so as not to be scratched, nicked, abraded, kinked or damaged in any way. If during stringing, it should prove inevitable to lower the conductors to the ground, suitable non-metallic lagging shall be placed underneath.

The conductors, joints and clamps shall be erected using the approved tools and in such a manner that no bird-caging, over-tensioning of individual wires or layers, or other deformation or damage to the conductor occurs.

Stringing tensions shall never exceed corresponding sagging tensions.

Clamps for attaching the conductors and overhead ground wires to the hauling device shall be of approved design and shall prevent the relative movement of strand or layers of the conductors or overhead ground wires. Freely rotating ball bearing swivels shall be used for each cable to be strung.

If, for any reason, stringing operations in progress must be interrupted, the conductors and overhead ground wires may be left in the stringing pulleys, but their tension shall be reduced as far as possible. In all cases, however, the cables must be kept completely clear of the ground, by approximately 3m, and sufficiently far from any obstacles which might cause abrasion of the cables, if touched by them.

If the interruption lasts for more than 40 hours or if stormy weather has prevailed, the cables shall be closely inspected for damage. Such inspection applies particularly to the suspension points where the cables have been resting in the pulley sheaves.

At all times during stringing, sagging and clamping operations, the conductors, overhead ground wires, reels and hauling plant shall be effectively grounded.

Damage to the conductors or overhead ground wires shall be immediately reported to the Employer who will instruct the Contractor on how to proceed.

Payment for the stringing and final tensioning of the conductor and OPGW shall be based on the horizontal route distance. The unit cost shall include for the wastage, sag length and jumpers of conductor and OPGW. No extra payment shall be given for wastage, sag length and jumper.

SAGGING

The "equivalent span" method shall be used for the line conductors and ground wire, according to which the tension in any line section, i.e., between two tension towers, is that which would apply to a single span equal to the square root of the figure arrived at by dividing the sum of the cubes of the individual span lengths, in the section considered, by their sum.

The Contractor shall submit for the approval of the Employer, sag and tension charts for use during erection, which shall be established with due regard to the specific stringing and sagging methods to be employed so that remaining creep after clamping may be assessed and taken into account with reasonable accuracy.

Erection sagging charts or tables shall display sag in still air against span length for temperatures between 5°C and 65°C in increments of 5°C.

Sagging temperature shall be read from a certified thermometer, the bulb of which has been inserted in an approximately 50cm long piece of conductor with the inner layers removed. The thermometer so equipped shall be freely suspended in the air without any shielding and not less than 3m above ground. Temperature readings will be taken only after at least 30 minutes exposure.

After finishing stringing operations, the conductors and overhead ground wires shall be sagged according to agreed sagging procedures and the relevant erection sagging chart or table.

It is essential that prescribed hold periods before definite sagging be rigorously observed.

The Contractor shall check the sag of each conductor and overhead ground wire of a sagging section in at least one span of approximate ruling span length. The sags shall also be checked in all spans exceeding 500m and in spans on each side of angle structures and sharp breaks in profile. Intermediate spans shall be inspected for uniform sag.

Sag will be subject to checking by the Employer, and the Contractor shall furnish such assistance in plant and personnel as may be required for this purpose.

Sagging sections shall be limited to such lengths as can be sagged satisfactorily.

Final sagging of conductors shall not be made earlier than 8 hours but not later than 48 hours after they have been taken up to approximate specific sag. All conductors of a sagging section shall be sagged at the same time.

Conductor tension shall be equalized between sagging sections so that the insulator strings will assume the proper position when successive sagging sections have been clamped in.

The Contractor shall keep a record on approved schedules of the particulars of the sagging of conductors and overhead ground wires in each sagging section.

CLAMPING-IN

After finishing sagging operations, the conductors and overhead ground wires shall be clamped-in according to approved procedures and the method statement. Tension clamps shall be installed and properly anchored prior to clamping-in at suspension strings. In order to make future adjustments possible, approximately one half of the available length adjustment of turn buckles shall remain after anchoring.

Clamping-in shall be completed within 48 hours after completion of sagging, unless otherwise agreed.

In transferring the conductors from the stringing pulley to the suspension clamps and during installation of the preformed armor rods, the conductors shall be carried by neoprene lined hooks with a saddle-shaped bearing surface long enough so as not to injure the conductors or any part thereof, or by equivalent means, as agreed with the Employer. The neoprene lining shall be electrically conductive.

Armor rods shall be installed in strict accordance with the manufacturer's instructions. They shall be centered within plus or minus 50mm. When installed, the difference between the ends of the rods shall not exceed 5mm.

All markings of the conductors, e.g., for the centering of clamps or armor rods, shall be done with tape or other inoffensive means. Scratch marks or similar will not be permitted.

Tightening torque of clamp bolts shall be as recommended by the manufacturer.

Immediately after clamping-in, sag tolerances shall be plus or minus 1% of the specified sag, provided that all conductors in the span assume the same sag, and specified clearances to ground are obtained.

Suspension insulators shall be plumbed longitudinally within plus or minus 30mm.

1.3.7.8 Vibration Dampers and Jumper Loops

VIBRATION DAMPERS
Vibration dampers shall be installed as specified after clamping-in. Dampers shall be located, installed, and clamped in accordance with the manufacturer's recommendations.

Stockbridge dampers shall hang plumb and in the same vertical line for each circuit after installation, with drain holes facing downwards. Before installation, all dampers shall be thoroughly cleaned and inspected for bent spring wires, distorted clamps or other damage.

Spacers and spacer dampers shall be installed in every span, in the same relative positions to each other, on all phases.

JUMPER LOOPS
Jumper loops shall connect all tension strings, between terminal fittings and shall be formed into a parabolic shape, for the minimum clearances specified on the tower outline drawings. To maintain minimum clearances under loop swing, the Contractor may utilize jumper loop suspension insulators (dolly sets), at no extra cost to the Employer. Pipe-type jumper loops may be proposed, subject to Employer's approval.

When setting compression jumper terminals, special care has to be taken to prevent any "basketing" of the conductor. After completion, the jumper loops shall present a smooth and uniform appearance without sharp bends.

At one terminal tower bottom cross-arm, jumper loops shall be transposed, to facilitate correct phase sequencing in the substations. This transposition shall be achieved with one normal and one extra large size jumper loop maintaining required minimum interphase clearance under all operating conditions.

1.3.7.9 Tower Earthing

All towers shall be permanently and effectively earthed. The individual tower footing resistance shall be less than 10 ohms with 5 ohms required for the first 4 towers on either side of the substation(s).

Individual tower earthing shall be made with earthing rods or when this is not possible, with a radiating earth conductor. In addition, the first four spans outside substations shall be equipped with a continuous counterpoise, which shall also be connected to the substation earthing grid. Earthing rods shall be driven to a depth as agreed with the Employer.

When installed, the top of the earthing rod shall be 0.6m (0.9m in cultivated areas) below the ground level. Each earthing rod shall be connected to the tower, as specified by the manufacturer. Each radiating earth conductor shall have a length as agreed with the Employer. The earth conductors shall be buried and connected to the tower as above. At each tower connection, a 2m extra loop of the groundwire shall be buried.

Continuous counterpoise shall be buried and connected to the steelworks and substation earthing grid as above for the first four spans outside the substations.

The earthing resistance for each tower shall be measured by the Contractor and the results submitted to the Engineer.

1.3.7.10 Spare Parts and Tools

SPARE PARTS AND TOOLS
In the schedule of prices, spare parts and tools are listed. These parts must not be used for erection or installation, except as agreed by the Employer.

Should the Bidder consider additional recommended spare parts advisable, these parts with separate prices are to be quoted in the price schedule.

The spare parts and tools shall be delivered to the Employer's stores as directed by the Employer. The spare parts and tools listed in the price schedule are calculated to be sufficient for the five year operation of the transmission lines.

The Employer shall have the right to increase by 100% or decrease, or delete all items of specified spare parts and tools within the contract completion time, without penalty to the Employer.

In case of any changes in specified quantities, the price for specified spare and tools shall be adjusted by applying the contract unit rates.

1.3.8 Inspection and Testing

1.3.8.1 Scope

The whole of the Works supplied under the Contract shall be subject to inspection and test by the Employer or their representative during manufacture, erection and after completion. The inspection and tests shall include, but not be limited to, the requirements of the Specification.

All plant, supervision, labor and services necessary to carry out all tests shall be provided by the Contractor unless specifically stated otherwise.

All expenses related to the factory tests of steel structures, conductor, OPGW, Insulators and Hardware shall be borne by the Contractor.

1.3.8.2 Quality, Assurance, Inspection and Testing

To ensure 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 a suitable quality assurance program to control such activities at all points necessary. Such a program shall be outlined by the Contractor and shall be accepted by the Employer after discussion before the award of Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

- Contractor's organization structure for the management and implementation of the proposed quality assurance program
- Documentation Control System
- Qualification data of Contractor's key personnel
- The procedure for purchases of plant, materials, parts, components and selection of sub-contractors' services including vendor analysis, source inspection, incoming raw materials inspection, verification of material purchases
- System of shop manufacturing including process controls and fabrication and assembly controls
- Control of non-confirming items and system for corrective actions
- Control of calibration and testing of measuring and testing plant
- Inspection and test procedures for manufacturer
- System for indication and appraisal of inspection status
- System of quality audits
- System of authorizing release of manufactured products to the Employer
- System for maintenance of records
- A quality plan detailing specific quality control procedures adopted for controlling the quality characteristics relevant to each item of supply

The quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

QUALITY ASSURANCE DOCUMENT
The Contractor shall be required to submit all Quality Assurance Documents at stipulated in the Quality Plan at the time of Employer's inspection of plant.

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.

1.3.8.3 Inspection, Testing and Inspection Certificates

The provision 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 previously inspected and approved by him at the Contractor's works, before and 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.

GUARANTEES

Bidders shall state and guarantee the technical data sheet and guarantee forming a part of the other sections of the bid document. These guarantees shall be binding and shall not be departed from without the written permission of the Employer. The tolerance permitted in the IEC, BS, ISO or ANSI Standards shall apply, unless stated otherwise.

1.3.8.4 Tests at Manufacturer's Works

GENERAL
Where no specific test is specified, then the various items of plant shall be tested in accordance with the BS, IEC, DIN, ANSI, ASTM Standards, or any recognized International Standards.

No plant shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been inspected or inspection has been waived by the Employer.

All instruments and plant used in the performance of tests shall be 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/Engineer.

The cost of carrying out calibrations shall be borne by the Contractor in all cases.

Within 15 days of the completion of any test, a triplicate set of all principal test records, test certificates and performance curves shall be supplied to the Employer/Engineer.

TYPE TESTS
Type tests are required to prove the general design of the plant. Type test reports of tests performed on similar plant within 5 years may be acceptable. In case some type tests are required by the Employer, then these tests prescribed shall be carried out at the Contractor's cost.

Tower Tests
Test on each type of towers to be supplied, shall be made at the manufacturer's plant or at such location as may be mutually agreed in accordance with IEC 60652.

Each test shall be performed in accordance with the following minimum requirements:

- Towers: The tower shall be fabricated from approved detail drawings in a manner as close to final production procedures as is practicable. The tower shall be complete in every detail.
- Erection: The tower shall be erected on a rigid foundation using the specified tower and bolts and nuts shall be tightened to the specific torque. It shall be vertical as far as possible or within acceptable tolerance.
- Rigging: The Contractor shall submit for approval as to compliance with the specifications, diagrams showing the proposed methods of applying loads and measuring deflections.
- Loading: All test loads corresponding to conductor and overhead ground wire loadings shall be applied directly to the regular attachments. Details shall be provided for these loads.
- Load Program: The Contractor shall program the tests to demonstrate that the towers will carry all design loads with conditions specified in the loading diagrams. Test wind loads on towers shall be the same as applied in design calculations.
- Deflection Measurements: Deflection shall be recorded for the "before load", "load on" and "load off" conditions, to provide longitudinal and transverse deflections at the tower top center, at the elevation of middle cross-arm(s) and at least one intermediate point of the tower body.

Design Load Tests

The initially applied loads and the increment of loading shall be 25% of the loads given in the loading diagrams. Each load increment shall be maintained for not less than two minutes for each assumption except under maximum (full) design loads where a period of five minutes shall be maintained and during which time there shall be no slacking off or adjustment of the loads. Should it become necessary to adjust the loading, the two or five minutes period shall re-start after the loading is stabilized and constant. All test loads shall be removed completely before the loads for testing under different assumptions are applied.

Destruction Tests

After the successful completion of the load tests, the tower shall be further tested to destruction by increasing the transverse loads under any condition specified by Employer in increments not to exceed five percent of full design transverse loads. The vertical and longitudinal loads are kept constant at their full design values while deflections are being recorded.

Modification of Tower Components

Any conspicuous yielding or any failure of any part of the tower under any of the tests specified in the sub-articles shall be considered a defect. If a defect develops, the Contractor shall modify the design of the tower and send to the Employer for approval. The modified tower shall then be retested at the Contractor's expense (including the cost of witnessing, if any) until the satisfactory results are obtained.

Material Tests

Steel materials used for tested towers shall be subject to tension or bend tests in accordance with ASTM A 370. Tests shall be performed by the Contractor at no additional cost to Employer. The test specimens shall be selected as follows:

- Two sets selected from the destroyed members of each tested tower
- Two sets selected from the undisturbed members of each tested tower.
- Reports: The Contractor shall furnish four certified copies of full reports of all tower and material tests, the calibration of the dynamometer or gauges, including clear photographs of the test set-up and nature of all failures, diagrams showing deflections of towers at each interval of loading, detailed diagrams and deflection records.
- Insulators: Insulators shall be tested in accordance with IEC 61109, IEC 60437. Insulator testing shall include the following, as a minimum:
    - Impulse voltage withstand flashover Test
    - Dry Power Frequency Withstand Voltage Tests
    - Wet Power Frequency Withstand Voltage Tests
    - Radio Interference Tests
    - Insulator Fittings Tests
- Conductor Tests: Conductors shall be tested in accordance with the requirements of BS 215 (Part 2), BS 3288. Conductor tests shall include the following as a minimum:
    - Routine Test
    - Operational Test
    - Clamp, Joint and Insulator Fittings Test
    - Insulators, Fittings and Conductor Overall Tests

SITE TESTS

Measurement of Footing Resistances

Before stringing the conductor, the footing resistance of each tower shall be measured with an earth resistance measuring instrument to the approval of the Employer.

Measurement of Earth Electrode (Counterpoise) Resistance
Where the footing resistance is found to exceed 10 ohms, or 5 ohms near substations, additional earth electrodes (Counterpoises) shall be installed and the combined earth electrode and footing resistance measured together and recorded using the same test instrument. Additional electrodes are to be installed to obtain a maximum resistance value of 5 ohms to10 ohms.

Measurement of Line Impedance
Positive and zero sequence impedance measurement tests shall be carried out after final line inspection has been completed. The measurement test shall be carried out on all new lines covered by this Contract, by the Contractor and at his own cost.

Conductor Joint Resistance Tests
In the case of tension clamps, joints and bi-metal terminals, the resistance of each part shall be measured by instruments supplied by the Contractor and approved by the Employer. The resistance of such fittings shall not exceed 80% of the electrical resistance of the equivalent length of Conductor. The tests shall be carried out in the presence of the Employer. Stringing shall not commence until suitable instruments are on Site, approved by the Employer and ready for use.

Measurement of Galvanizing Thickness
The Contractor shall have available on Site for the Employer's use, an instrument suitable for the accurate checking of galvanizing thickness. The gauge shall be available from the time of arrival of the first consignment of steel work until the issue of the Operational Acceptance Certificate. The cost of the gauge and other operating expenses are deemed to be included in the Contract Price and the gauge will remain the property of the Employer.

Tests on Completion
Acceptance tests shall be carried out on site by the Contractor only after the completion of whole works.

The line shall be energized at full working voltage before handing over and the arrangement of this, and such other tests as the Employer shall require to make on the complete line, shall be assisted by the Contractor who shall provide such labor, transport and other assistance as is required without any extra charge. Plant for special tests shall be provided by the Contractor.

The Contractor shall submit to the Employer at least two months before the anticipated commencement of acceptance tests, the detailed proposal for carrying out acceptance tests.

Test Instruments
The method of measuring all quantities and qualities and the measurement tolerances shall be in accordance with the appropriate BS, IEC, ISO or ANSI Standards.

The terminal conditions required for establishing that guarantees are met shall be measured by precision test plant to be installed by the Contractor in addition to the permanent measuring plant where supplied under the Contract.

The overall design of the Works shall provide for the installation and use of test plant so as not to interface with the plant loading or delay the guaranteed completion dates.

All the precision test plant to be used for tests shall be calibrated against standard instruments before the tests, and if required by the Employer, also after the tests. Calibration certificates shall be available for inspection by the Employer or his representative.

During the design stage of the plant, the Contractor shall give details of measurements to be made to substantiate that the performance of the plant meets the requirements of the specification and in particular shall submit for approval a schedule of performance test instructions necessary to demonstrate the guarantees.

Test Reports
For each of the specified tests, the Contractor shall agree the test figures with the Employer and shall submit for review and approval triplicate copies of the test reports containing a complete analysis of the test results within one month of the completion of the relevant tests. Five (5) copies of the final approved report shall be submitted to the Employer.

Field Test Quality Plan
The Contractor shall develop field test quality plan so that conducted test results can be recorded accurately.

Commissioning Tests
The Contractor shall be responsible for checking that total and relative sags of conductors are within the specified tolerance. If the Employer wants to check, the Contractor shall provide the necessary survey instruments to enable the checks to be carried out with the line in service without any extra charge.

The Commissioning Tests are as follows:

- Measurement of Line Parameters
- High Voltage Tests
- Phase Tests
- Continuity Tests

COST OF TESTS AT MANUFACTURER’S WORKS
All cost related to the any tests to be performed at the manufacturer’s works, site and elsewhere for testing and witnessing by the Employer shall be borne by the Contractor. This cost shall include furnishing plant, construction, erection, testing, visas and travel documents, airfares, ground transportation, acceptable accommodation, meals, daily allowance (@$150/day/person cash in advance), etc.

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 plant. The number of the Employer’s and Engineer’s personnel and plant to be witnessed shall be as listed below. The duration of such visits shall be as per inspection/testing requirements.

Table 1.3.8 Tests at Manufacturer's Works

Type of Test	Visitors/Person	No. of Visits
Conductor Type, Routine, Witness Test	Employer (4)+Engineer (1)	One (1) Visit
OPGW Type, Routine, Witness Test	Employer (4)+Engineer (1)	One (1) Visit
Tower Type, Routine, Witness Test	Employer (4)+Engineer (1)	Five (5) Visit
Insulator Type, Routine, Witness Test	Employer (4)+Engineer (1)	One (1) Visit
Hardware and Fittings, Type, Routine, Witness Test	Employer (4)+Engineer (1)	One (1) Visit

If the Employer requests another test inspection after a successful test, the travelling expenses of the inspectors nominated by the Employer will be borne by Employer.

However, the Contractor shall bear all expenses incurred due to the repetition of any test due to:

- Failure of the first test
- Test facility not ready at the time of inspection or mismatch of test schedule/program provided by the Contractor

1.4 Technical Requirements – Substation Equipment

The substation designs shall conform to conceptual design drawings included in Volume 2, Section 4.0.

1.4.1 220kV Primary and 20kV Secondary Equipment

1.4.1.1 General

All 220kV and 20kV primary equipment shall be designed and manufactured in accordance with the latest edition of IEC standards. This includes the following main applicable standards:

- IEC 60044 Instrument transformers
- IEC 60099 Surge arresters
- IEC 60265 High voltage switches
- IEC 60282 High voltage fuses
- IEC 60694 Common specifications for high voltage switchgear and controlgear standards
- IEC 61166 High-voltage alternating current circuit-breakers - Guide for seismic qualification of high-voltage alternating current circuit-breakers
- IEC 60071 Insulation Coordination
- IEC 60255 Electrical relays
- IEC 60273 Post Insulators
- IEC 60502 Power Cables
- IEC 62271 High-voltage switchgear and controlgear.

All 220kV primary equipment and accessories shall be air insulated and installed outdoors. 20kV secondary equipment and accessories shall be installed indoors.

Specified clearances shall be considered minimums. The supplied values are elevation dependent and have been provided for information only. The designer shall consider elevation and adjust clearances tendered and applied to equipment design.

1.4.1.2 220kV and 20kV Circuit Breakers and Disconnector/Earthing Switches

The circuit breakers and disconnector/earthing switches shall be rated in accordance with Table 2.4.1.

Table 1.4.1 Circuit Breaker and Disconnector/Earthing Switch Rating

Rated voltage	245kV	24kV
Rated normal current	1,250A transformer bay 1,600A busbar bay 1,250A line bay	1,250A transformer bay 1,250A busbar bay 630A line bay
Rated short-circuit breaking current	40kA, 3 second	25kA, 3 second
Rated insulation level	1,050kV	125kV
Rated 1 minute power-frequency withstand voltage (rms) to earth and between poles	460kV	50kV

Circuit Breakers
The 220kV circuit breakers shall be of SF6 type. The 20kV circuit breakers shall be indoor metal clad of vacuum or SF6 type. General electrical requirements shall comply with the parameters collected in Table 2.4.2.

Table 1.4.2 Circuit Breakers

Nominal system voltage	220 kV	20 kV
Rated class	Outdoor	Indoor
Rated operation sequence	0-0.3s-CO-3m-CO	
Rated making current	2.5 times the rated breaking current	
Rated out-of-phase	25% of rated short breaking current circuit breaking current	
Total breaking time	50ms	
Total closing time	60ms	

Circuit breakers shall be equipped with motor-charged spring operated mechanism for 220V-DC. The motor-charged spring-operated devices shall have a direct-on-line starter. It shall be possible to set the operating spring manually with a hand-crank. Motors shall be designed in accordance with valid IEC publication and operate correctly between 85% and 110% of rated voltage. The motors shall be effectively protected. The motor circuits shall be controlled 2-pole (Phase) from the motor-protection and end-position contacts. An auxiliary relay for alarm shall be connected to the motor-voltage and have a closed contact for no voltage, tripped motor-protection and unloaded spring.

The operating mechanism shall be provided with an anti-pumping device.

The circuit breaker shall have 220V-DC shunt coils for closing and duplicate tripping. The coil and relays in the closing circuits shall operate correctly between 85% and 110% of the rated voltage. For tripping circuits the limits are 70% and 110%.

The operating devices shall be equipped with a selector switch for local and remote control.

Manual closing for maintenance work shall be possible. Manual tripping (mechanical) shall be possible even in the absence of supply voltage for emergency situations, unless the breaker is locked out.

One set of auxiliary contacts necessary for control purposes shall be mechanically linked to the circuit breaker. All contacts shall be wired and connected to terminals in the cubicle.

A switch shall be provided for the operating voltage for each circuit breaker. The switch shall, in the open position, prevent all electrical operations of circuit breakers. The switch shall have at least 10 contacts and be labeled OPERATION.

The mechanism shall be provided with an operation counter for at least 9999 CO-cycles.

Disconnectors
The disconnectors shall be of center break or center rotating type with horizontal operation. All disconnectors shall provide the possibility for a manual operation with a hand crank. General electrical requirements shall comply with Table 2.4.3.

Table 1.4.3 Disconnectors

Nominal system voltage	220kV	20kV

Nominal system voltage	220kV	20kV
Rated lightning impulse withstand voltage		
To earth and between poles	1,050kV	125kV
Across isolating distance	1,200kV	145kV
Rated 1 minute power-frequency withstand voltage (rms)		
Across isolating distance	530kV	60kV

Disconnectors with a manually operated earth switch shall be provided with a mechanical interlocking between the disconnector and the earth switch to prevent closing of the earth switch when the disconnector is in the closed position.

The disconnector and the earth switch shall be possible to lock with padlock in open and closed position. Earth switch shall have an earthing platform, suitably connected to the earthing grid at not less than 2 points of connection, of size not less than 3m x 3m installed under the switch handle mechanism for operator safety when operating the earthing switch manually.

Motor operated disconnectors shall be designed with three-pole operation and shall operate on 220V-DC. The motor shall be designed in accordance with valid IEC publication and work correctly between 85% and 110% of rated voltage. The motor shall be effectively protected. Electric control shall always be two-pole to avoid maloperation in case of earth faults.

Motor operated disconnectors shall be designed for control and position indication from remote. The operating device shall be equipped with a selector switch for local and remote control.

1.4.1.3 20kV Switchgear

The equipment shall comply with the requirements of the appropriate IEC standards and comprise a metal enclosed, free-standing switchboard suitable for indoor application, dust and vermin proof and suitable for coordination with a 20kV, 3-wire system.

Design of the switchgear shall allow good accessibility with maximum personnel safety during operation, inspection and maintenance. Also maximum segregation shall be afforded between cubicles and between high and low voltage sections within the cubicles.

The 20kV circuit breakers shall be fitted with an auto-recloser relay, designed for automatic reclosing of the line in case of transient over current or earth faults. The relays shall lockout further operation after two unsuccessful attempts at reclosing.

Where required, the switchboard shall be complete with all necessary contacts, transducers etc. to provide full compatibility with the system SCADA.

The single line diagrams illustrate the equipment specified. The switchgear shall be suitable for the 20kV, 3- phase, 3-wire, 50Hz section, with the neutral solidly earthed at the 220/20kV transformer. The source of 20kV supply is the zone substation transformers at each substation. Provision shall be made for future extension of the switchgear at either end.

The 20kV three phase busbars contained within the metal clad switchgear shall be installed in a conventional manner and shall be completely screened in a chamber running the length of the switchboard. Busbars shall be fully insulated busbars along their entire length with high dielectric strength sleeving.

Inter-panel connections shall be via insulated barriers designed to preserve an effective seal between cubicles under the most severe arcing fault conditions.

The busbars shall have a current rating of 1,250A and all components of the busbar system shall be able to withstand the stresses imposed by vibration, short circuits, thermal expansion or other causes.

The circuit breakers shall be of the vacuum or SF6 type as specified in Clause 2.4.1.2, carriage mounted for horizontal withdrawal. They shall be spring operated with a 230V-AC. single-phase motor for charging the springs. The springs shall also be able to be manually charged. The circuit breaker closing the tripping coils shall be 220V-DC. The operating mechanism shall be trip free. All circuit breakers shall be fully interchangeable between circuits.

A mechanical means shall be provided to show whether the circuit breaker is open or closed. Electrical/mechanical interlocks shall be provided to ensure that:

- the circuit breaker may only be withdrawn when open
- the circuit breaker may only be restored to the service position when open.

Auxiliary contacts, including 2-n/o and 2-n/c spares, shall be provided and wired out to terminal blocks, to be used for remote indications. Provision shall be made for operating the circuit breaker in the withdrawn position for test or maintenance purposes.

Each circuit breaker shall be equipped with a circuit breaker condition indicator that shall record the opening speed of the contacts, the gas pressure (if applicable) inside the poles and the wear of the breaker poles. At exceeded limits an alarm shall be given for remote indication.

The circuit cubicle shall be equipped with a door at the front that shall support the circuit breaker on its carriage when withdrawn into the maintenance position. The door shall have a window through which the circuit breaker condition indicator and mechanical open/closed indicator are viewed. The insertion or withdrawal of the circuit breaker from the service position shall be carried out with the door closed by means of a racking mechanism indicator operated by the racking mechanism and visible on the front panel of the racking mechanism.

The circuit cubicle shall be arranged so that the busbars and circuit connections are completely screened when the circuit breaker is withdrawn. Automatic shutters shall be operated by the circuit breaker truck to screen both the busbar and circuit fixed contacts when the circuit breaker is withdrawn. The shutters shall be clearly labeled “BUSBARS” and “CIRCUIT” and provided with means for padlocking in the closed position.

The high voltage cable termination compartment shall be equipped for the termination of the cable cores of the three phase circuit connections.

This surge arrester cubicle shall be equipped with three 24kV surge arresters connected between each phase of the busbars and the earth bar.

A surge arrester shall be provided with a counter able to be read from the front panel of the cubicle.

Current transformers shall be mounted in the cable compartment and shall be of the insulated bar primary type unless otherwise approved. Secondary windings shall be earthed at one point only and means shall be provided to short circuit these windings. All necessary terminals and rating plates shall be provided and characteristic curves shall be submitted for each current transformer.

Voltage transformers shall be single phase units, for three phase applications three single phase units shall be connected in star. Class 0.5 shall be provided for measuring applications and class 3P for protection.

An earth busbar shall be run internally through the length of the switchboard. All non-current carrying metalwork earth switches, surge arresters, CT and VT secondary circuits, etc. shall be bonded to this earth busbar. A fixed/moving contact arrangement shall be provided for the positive earthing of the circuit breaker carriage.

Each circuit cubicle shall be provided with an integral fault making earthing switch for the safe and effective earthing of the ‘circuit’ connections. In addition, the surge arrester cubicle shall accommodate an equivalent earthing switch for the earthing of the busbars. The earthing switches shall be interlocked with their associated circuit breakers. The earthing switches shall be manually operated from the front of the switchgear panel.

1.4.1.4 220kV and 20kV Current Transformers

The current transformers shall be rated in accordance with Table 2.4.4.

Table 1.4.4 Current Transformers

Current Transformers	
Location	220 kV Line Bay, Transformer Bay, and Bus Coupler
Rated voltage	245 kV
Core 1 & 2 assignment	200-500-800-1200/1A, Class PX, Vk=1500V, Rc < 6 ohms, Ie < 25mA
Core 3 & 4 assignment	1200-2400/1A, Class PX, Vk=1500V, Rc < 12 ohms, Ie < 50mA
Core 5 assignment	200-500-800-1200/1A, Class 0.2, 25VA
Location	220kV Transformer Bay (10MVA Transformer)
Rated voltage	245kV
Core 1 & 2 assignment	10-20-40-80/1A, Class PX, Vk=1500V, Rc < 6 ohms, Ie < 25mA
Core 3 & 4 assignment	10-20-40-80/1A, Class PX, Vk=1500V, Rc < 12 ohms, Ie < 50mA
Core 5 assignment	10-20-40-80/1A, Class 0.2, 25VA
Location	20kV Transformer Bay (4MVA or 10MVA), 20kV Bus Sectionalizer Bay
Rated voltage	24kV
Core 1 & 2 assignment	100-200-400-800/1A Class PX, Vk=1500V, Rc < 6 ohms, Ie < 25mA
Core 3 assignment	100-200-400-800/1A, Cl 0.2, 25VA
Location	20kV Line Bay
Rated voltage	24kV
Core 1 assignment	100-200-400/1A, Class PX, Vk=1500V, Rc < 6 ohms, Ie < 25mA
Core 2 & 3 assignment	100-200-400/1A, Cl 0.2, 15VA

Earthing of secondary windings shall be done through a disconnectable terminal inside the low-voltage cabinet. Unused cores shall be wired to terminals and short-circuited in the low-voltage cabinet.

A legible circuit-diagram plate showing the transformer connection and terminal markings, shall be permanently fixed inside the low-voltage cabinet. The separate main data for the different cores shall be shown on the plate.

1.4.1.5 220 kV and 20 kV Voltage Transformers

The voltage transformers shall be rated in accordance with the following data:

Table 1.4.5 Voltage Transformers

	220 kV	20 kV
Voltage ratio	220kV/√3, 110V/√3, 110V/√3	20kV/√3, 110V/√3, 110V/√3
Accuracy/Burden Secondary	0.2, 100VA	0.2, 100VA
Accuracy/Burden Tertiary	3P, 100VA	3P, 100VA
Type	Capacitive	Inductive

Rated voltage factor shall be as follows:

- Between phase and earth continuous 1.2
- Between phase and earth, 30 second 1.5

Earthing of secondary windings shall be done through a disconnectable terminal inside the low-voltage cabinet. Each secondary winding shall be protected with individual miniature circuit breakers (MCB) or fuses. To prevent maloperation of relay protection, interlock system, etc. a supervision device for the MCBs or fuses shall be provided.

A legible circuit-diagram plate showing the transformer connection and terminal markings shall be permanently fixed inside the low-voltage cabinet. The separate main data for the different cores shall be shown on the plate.

1.4.1.6 220kV and 20kV Lightning Arresters

The lightning (surge) arrestors shall be rated in accordance with Table 2.4.6.

Table 1.4.6 Surge Arresters

System voltage	245kV	24kV
Rated voltage (Ur IEC 60099-4)	198kV rms	24kV rms
Energy Capability Class	Class 3	Class 2
Nominal discharge current	10kA peak	10kA peak

The surge arresters shall be of ZnO-type and heavy-duty station class. One common surge counter per three-phase group of arresters shall be provided.

1.4.1.7 Medium and High Voltage Terminals

Terminals shall normally be of module plate type. If the terminal is a direct extension of an internal conductor as for bushings or current transformers, pin type is accepted as an alternative.

Copper or copper alloy terminals shall be tinned to a thickness of minimum 50μm. Copper alloys shall not be sensitive to season cracking. Aluminum or aluminum alloy terminals shall not be treated. Aluminum alloys sensitive to layer or inter crystalline corrosion shall not be used.

1.4.2 Power Transformer

1.4.2.1 Reference Standards

All transformers shall be designed and manufactured in accordance with the latest edition of IEC standards. This includes the following main applicable standards:

IEC 60076	Power Transformers
IEC 60137	Insulating bushings for alternating voltages above 1000V
IEC 60214	Tap-changers
IEC 60296	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
IEC 60354	Loading guide for oil-immersed transformers
IEC 60529	Degrees of protection provided by enclosures
IEC 60542	Application guide for on-load tap-changers

1.4.2.2 General Design

Power transformers shall be 3 phase, oil immersed consisting of a complete independent unit with on-load tap changer (OLTC), outdoor bushings, surge arrestors, cooling equipment, auxiliaries and accessories. All transformers supplied shall be installed outdoors and shall be required to operate under the system characteristics and climatic conditions specified in Section 2.2.5. Each transformer shall produce its full rated power at its designated substation after applying any derating factors due to climate and altitude. The transformers shall comply with IEC 60076.

The power transformers shall be located and rated in accordance with Table 2.4.7.

Table 1.4.7 Power Transformers

	Salang Tunnel
Type	Transformer
Rated Power	4MVA
Rated Frequency	50Hz
Impedance Voltage	10%
Vector Group	YNyn0d11
Cooling	ONAF

The transformers shall be capable of operating continuously at the specified output and at voltages at 10% higher than the rated voltages at any tap without undue heating, vibration, noise and other operating difficulties. All items, except for windings, shall be designed for continuous current of 120% of the rated current, without exceeding the temperature rises prescribed in the Standards.

The electrical supply will be 400/230VAC available for operation of electric motors required for the proper operation of the power transformer.

1.4.2.3 Losses

The losses shall be stated and guaranteed in the Bid schedules. The capitalized value of the guaranteed losses will be taken into account when comparing Bids and will be added to the Bid price. The losses will be capitalized at the rates as follow:

- No load loss: US$ 6,500 per kilowatt
- Load loss: US$ 1,500 per kilowatt applied to the total transformer capacity proposed by the Bidder.

The guaranteed losses are to be maximum values and shall not be exceeded. If the tested losses exceed the guaranteed losses but are within the tolerances allowed in IEC 60076 then losses in excess of the guarantees shall be capitalized at the evaluation rate and the amount deducted from the contract price. There will be no credit for losses under guarantee.

The values for losses stated by the Contractor in the Bid Documents shall be verified during the factory tests.

The Employer has the right to reject transformers that exceed the tolerances allowed by IEC 60076.

1.4.2.4 Cooling System

Transformers shall be capable of operating continuously at full load utilizing ONAF (or ODAF) type cooling. The manufacturer shall advise the maximum reduced rating output power with the cooling fans out-of-service.

The coolers shall be of the fin type, fully hot-dip galvanized, detachable and equipped with lifting eyes, vent holes with plugs, plugs for filling and draining and with shutoff valves to permit the removal of any cooler without draining the oil from the transformer tank. The coolers shall be removable during operation of the transformer. All radiator isolating valves shall be fully oil tight and vacuum capable and shall be mounted to the transformer and radiator by bolted flanges.

Only transformers less than 10MVA shall have radiators mounted directly to the transformer tank, all other transformers shall be mounted via a manifold. ODAF designs shall have main and standby oil circulating pumps.

1.4.2.5 Temperature Rise

In continuous service, at the specified ratings, the rise in temperature above the ambient air shall not exceed 60°C for the windings and 55°C for the top oil.

For cores and other parts the rise in temperature shall, in no case, reach a value that will damage the core itself, metallic parts or adjacent materials.

1.4.2.6 Short-Circuit Withstanding Capability

The transformer shall be designed and constructed to withstand, on any tapping, without damage:

- Thermal and mechanical effects of any short-circuit (three-phase short-circuits and solid line-to-ground short circuits, etc.) that can appear at the terminal of any winding
- Transportation or impact forces of 3g or greater.

1.4.2.7 Vibration and Noise Levels

Special attention shall be given in order to avoid undue vibrations and noise in the transformer.

1.4.2.8 On-Load Tap Changer

General
On-load tap changers (OLTC) for manual control and electrical remote control shall be provided. The OLTC shall comprise a tap selector with changeover switch and a rotary diverter switch of high-speed transition resistor type. The OLTC shall be in conformity with IEC 60214 and IEC

60542. Only designs that have been type tested in accordance with the relevant IEC standards will be accepted.

The OLTC shall be mounted from the cover into the transformer tank at narrow sides of the transformer tank. The diverter switches and/or selector switches shall have oil compartments separate from the transformer oil as well as their own closed sub-sections in the oil conservator.

The tap changer head shall be equipped with a bleeding duct to be connected to Buchholz relay of main tank to avoid any gas collection underneath the tap changer head outside the diverter switch compartments. No piping or other equipment shall be arranged beyond the tap changer head to allow lifting of the diverter switches and/or selector switches without removing (dismantling) of any other equipment.

An oil-flow operated protection relay and a sudden-pressure operated protection relay shall be provided for internal failure protection. In addition a spring-loaded pressure relief device with trip contact shall be mounted directly onto the tap changer head.

The power of the transformers shall remain constant at all tap positions, and the OLTC shall be capable of successful tap changes for the maximum current to which the transformer can be loaded.

The permissible continuous through-current of each tap changer unit at rated switching capacity shall cover all cyclic loading duties as per IEC 60354 at highest current tap and at rated system operation voltage applied on the transformer terminals.

The OLTC shall withstand all kinds of through-fault currents for at least 3 (three) seconds without damage.

The motor drive, plus all auxiliary equipment for operation of the tap changer, shall be incorporated in a control cabinet made, protection class IP66, and shall be mounted onto the transformer tank in a convenient floor height.

The complete wiring shall be of highly flexible stranded copper and furnished with slip-over ferrules at both ends. Wiring shall also have crimped termination. The minimum cross-section of the wiring other than for step-position transmitters shall be 2.5mm^2.

The electrical supply will be 400/230VAC available for operation of electric motors required for the proper operation of the power transformer. The AC supply of the motor drive cabinet shall occur via the control cabinet for cooling equipment or marshalling box and an appropriate MCB with trip contact shall be provided in the concerned cabinet for the outgoing auxiliary supply cable.

The cabinet shall be mounted on a narrow side of the transformer and the following main equipment shall be installed:

- Driving motor with complete motor protection equipment
- Operation counter
- Control switch or push buttons for local raise/lower operations (properly protected against unauthorized operation)
- Electrical limit switches
- Mechanical stops in end positions
- Step position indicator ("1" related to the position with the maximum high voltage)
- Local/remote switch

- Voltage supervisory relays for all phases of supply voltage and main circuits of control voltage
- MCBs for driving motor and each auxiliary supply circuit
- Hand lamp (controlled via door contact)
- One heater, thermostatically controlled
- Minimum one conventional position transmitter of the resistor type
- Additional end position contacts
- Spare plug socket LV, AC (BS) with MCB 10A
- Terminal blocks with terminals of single insertion type with isolating facilities and test connectors and being universally suitable for connection of solid conductors from 0.5 mm^2 up to a cross-section of at least 10 mm^2 (Phoenix or equivalent), with ten percent spare terminals on each terminal block
- Crank handle for manual operation
- Padlock facilities for front door
- All equipment installed in the cabinet shall be designed for a cubicle inside temperature of at least 70°C
- A rigid pocket for storing the related paper drawings shall be securely fixed on the inner side of the door of this cabinet.

The motor drive shall meet the following requirements:

- Mechanical indication of step position at the motor drive cabinet
- Transmission of step positions of the transformers to the local control room
- Manual operation in the case of a failure in the electrical supply system
- Step-by-step operation with automatic stop after each step
- Automatic restart of tap changing operation in the case of a failure in the electrical supply system, interlocking to be provided against simultaneous raise/lower operation
- Blocking of end positions by means of limit switches
- Provisions to be made for parallel running and automatic operation controlled by a voltage regulating device and parallel control unit.

Parallel Operation and Voltage Regulation
The power transformers shall be able to be operated in parallel at a future date.

Performance Characteristics of Motors
- The motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
  - Variation of supply voltage from rated motor voltage ±10%
  - Variation of frequency ± 5%
  - Combined over or under excitation ±10%
- The motor shall be capable of starting and maintaining the load with the applicable method of starting without exceeding acceptable winding temperature when the supply voltage is in the range of 85% of the rated supply voltage
- The motor shall be suitable for full voltage direct on line starting
- AC motors shall be of the three-phase type
- Motors less than 3.7kW may be single phase
- The vibrations of motors shall be within the limits specified in applicable standards
- Insulation shall be given fungicide treatment suitable for extremes of hot and cold climate.

1.4.2.9 Core

The flux density in the core shall not exceed 1.70 Tesla during normal operation at rated primary voltage on nominal tap and at rated frequency with no over-fluxing occurring.

The core shall be made of high grade, unaging, cold rolled grain oriented steel. Laminations shall have low losses and high permeability. Insulated packets of the core are to be connected so that no potential differences will exist between them. Flux distortion shall be minimized to reduce noise level.

The cores, framework, clamping arrangements, shall be capable of withstanding any shocks to which the equipment may be subjected during transport and operation.

Both the core and frames shall be earthed via a single point earthing design where each connection to either the frame or core is brought out through separate 2kV bushings complete with removable bolted shorting links that connect them to an earth stud on the transformer tank lid. All components shall be rated for the maximum possible circulating current should the core or frame becomes inadvertently earthed. The bushings located on the transformer lid shall be protected from inadvertent physical damage by a removable cover or similar.

1.4.2.10 Windings

The turns in coils shall be thoroughly treated in such a way as to develop the full mechanical and electrical strength of the transformer. Oil from radiators shall be directed into the bottom of each winding.

All windings 220kV and above connected in star shall have graded insulation; and all windings rated less than 220kV shall be fully insulated.

The transferred voltage from one winding to any other winding when open circuited shall not exceed the impulse test voltage of that winding. Where windings do not meet this criteria then surge arrestors located in their own separate compartment located outside the main tank shall be used to restrict such transferred voltages to the specified impulse levels.

All winding conductors and connections shall be manufactured from burr free profiled high conductivity copper or aluminum. All electrical connections within the windings shall be fully brazed or welded and capable of withstanding all shocks encountered in service, transport, earthquakes etc. All connections from windings shall be mechanically sound and fully supported.

All cylinders and wraps shall be made from pre-compressed transformer board. All cylinder joints shall be fully scarffed with overlaps being made only on duct strips. Only fully molded caps and collars are acceptable; designs utilizing “Petal” collars or caps are not acceptable.

When used, enamel covered wires shall have a minimum radial thickness of 0.05mm and where cross-overs or transpositions occur they shall be mechanically and electrically protected.

No electrical out-of-balance turns will be acceptable between phase windings. All duct strips and spacers shall be full contoured and shall be of a solid construction, strips and spacers stacked together are not acceptable. All paper covered conductors shall use thermally upgraded paper. All continuously transposed conductors shall be fully epoxy bonded to withstand all free buckling and short circuit forces.

1.4.2.11 Tank

The tank shall be constructed of high-grade steel plate, suitable reinforced to withstand handling and pressure during faulty condition without any destruction. The tank shall be provided with manholes, valves and de-aerating cocks as may be required for the prescribed maintenance of the transformer. The tank shall be provided with earthing terminals for a wire of $95mm^2$ at two opposite sides of the tank.

1.4.2.12 Corrosion Protection

The corrosion protection shall be carried out as specified in Clause 2.13 in the General requirements.

1.4.2.13 Oil

All oil used during the manufacture of the transformer shall be free of all additives. Oil supplied for the filling of the transformer shall be new and shall contain at least 0.3 per cent by weight oxidation inhibitor of type di-tert-butyl-para cresol (DBPC) according to IEC 60296.

The oil shall not contain PCB. If oil samples taken from the transformer on delivery contain 2ppm or more PCB, the Employer shall have the right to refuse the delivery of the transformer.

1.4.2.14 Bushings

Bushings shall be of type stated in IEC 60137.

Connections from the windings to the bushings shall have the necessary flexibility. The bushings shall be installed so that they are easy to check and place, without removing the tank cover pipe work.

The star point of the winding shall be separately bought out through the tank lid by means of an outdoor bushing, located so that it cannot be associated with the main phase bushings. All bushings shall have permanent phase markings adjacent to the bushing flange.

1.4.2.15 Accessories

The following accessories shall be provided for the transformer:

- Oil temperature indicator for the top oil equipped with a maximum reading device individually insulated and a minimum of two separately adjustable contacts for alarm and tripping, with all immersed parts able to be removed without the need to interfere with the tank
- Winding temperature indicator shall be equipped with a maximum reading device individually insulated and a minimum of two separately adjustable contacts for alarm and tripping, with all immersed parts able to be removed without the need to interfere with the tank
- An aseismic Buchholtz relay for gas protection with a minimum of two non-mercury separate contacts for signal and tripping. A gas capture and test device shall be connected to the Buchholtz and located adjacent to the control cubicle
- Oil level indicator equipped with a minimum of two separately adjustable contacts for alarm and tripping
- Oil drying device, type Silica Gel breather
- Terminal box equipped with disconnect able terminals for signal cables to the auxiliary cubicle

- The on-load-circuit tap changer shall be provided with a mechanism for automatic operation. The operating mechanism shall be provided with a tap position indicator.

1.4.2.16 Routine and Type tests

General
Full and complete testing of the transformer with accessories shall be carried out according to the relevant IEC Standards. The more important tests are listed below.

The Contractor shall give a complete description of the proposed test methods. The test methods and the performance of the test shall be subject to the approval of the Employer / Engineer. All instruments and equipment necessary for the testing shall be provided by the Contractor.

Test Particulars
Testing shall include but not be limited to the following:

- When a transformer is to be subject to a temperature rise test, dielectric test including an impulse test shall be carried out as soon as practicable after this test, that is whilst the transformer is still hot
- The no-load losses and the current of the transformer shall be measured at 90%, 100% and 110% of rated voltage before commencement of the dielectric test. The no-load losses and current measured after completion of the dielectric test shall be the values used in determining the performance of the transformer
- Impulse test shall be applied on all transformer terminals, including neutrals. Impulse test oscillography records shall be made
- Noise level measurements shall be carried out according to IEC 60076
- Bushings shall be fully tested according to IEC 60137
- Insulation power factor tests shall be performed with bushings in place.

Type Tests
The following type tests shall be carried out. The tests shall be according to IEC 60076, except where otherwise specified.

- Temperature rise test
- Zero sequence impedance
- Noise level
- Examination of harmonics
- Tests on bushings

Routine Tests
The following routine tests shall be carried out. The tests shall be according to IEC 60076, except where otherwise specified.

- Winding resistance measurements on all windings
- Ratio tests on the rated voltage connection
- Polarity tests
- No-load loss at 90%, 100% and 110% of rated voltage
- Exciting current at 90%, 100% and 110% of rated voltage
- Impedance and load loss at rated current
- Separate source withstand tests
- Induced voltage tests
- Impulse voltage withstand tests on all windings. Full wave and chopped wave

- Pressure tests on tank and coolers for oil tightness. If a temperature test is made, the pressure test shall
- be made while the transformer is still hot
- Operational tests of all devices and wiring
- Insulation tests on auxiliary devices and wiring
- Test on bushings

1.4.3 Earthing System

1.4.3.1 General

The station earthing system shall be designed according to IEEE 80 Guide to Safety in Substation Grounding. The earthing system shall consist of buried conductor loops around the substation building and the transformer foundation. The loops shall be connected to an earth bar inside the building. Connections to the earth bar shall be possible to disconnect. The connections shall be clearly labeled. To reach the desired earth resistance, additional grounding rods shall be installed and connected to the earth bar.

Connections shall be made by compressed clamps or by an approved welding process. No bolted clamps may be used under the ground surface. Connections to steel structures (riser connections) shall be made by compressed lugs with two holes in the contact pad. Risers or earth conductors shall not touch cables.

1.4.3.2 Earthing Parameters

The earthing system shall comply with Table 2.4.8.

Table 1.4.8 Earthing System

Earthing System		
Minimum sizes of copper conductors		
	Grounding loops	120mm^2
	Riser	120mm^2
	Connection of live neutrals	50mm^2
	Connection of other steelworks not part of high-voltage structures	25mm^2
Maximum permissible fault current density for connection of:		
	System neutrals	100A/mm^2
	HV-equipment	200A/mm^2
	LV-equipment auxiliary power transformers, etc.	150A/mm^2
Grounding rods		
	Diameter	16mm
	Length, minimum	3m
	Material	Copper-clad steel
Assumption for calculations of step voltages, according to IEEE-80		
	Maximum grid potential rise	5kV r.m.s.
	Step	1m
	Body resistance	1000Ω
	Fault clearing time	1s
Assumption for soil resistivity for use, according to IEEE 80		
	Common Soil resistivity	3,000Ω-m

1.4.3.3 Earthing of Enclosures

An earthing conductor of a sufficient cross-sectional area shall be provided extending the whole length of the switchboards and control cabinets. All metal parts of the enclosure/cubicle shall be earthed by risers from the conductor loop.

1.4.3.4 Earthing of Other Types of Equipment

Earth terminals of LV equipment shall be earthed by wire designed for the actual earth fault current.

Connection and marshalling cubicles, etc. for LV or control equipment shall be connected to the earthing system irrespective of whether they are mounted on otherwise grounded structures or not. Cubicle doors, where electrical apparatuses or instruments are installed, shall be earthed by a flexible earthing cord.

1.4.3.5 Temporary Earthing Devices

Two three-phase sets of temporary earthing devices with leads of sufficient length and short circuit capacity, one for each winding, shall be delivered for each transformer. One three-phase set of temporary earthing device with leads of sufficient length and short circuit capacity shall be delivered for the 20kV switchgear.

The design and test methods for temporary devices are subject to approval of the Employer. Both the phase conductor and the steel structure shall always have fixed contacts.

Earthing devices shall be designed for 1-second duration of the specified fault current. Earthing switches in connection with disconnectors shall be designed for the same fault current as the disconnectors.

1.4.3.6 Corrosion Risks

The Contractor shall be observant of the risks for corrosion of buried galvanized steel structures if connected to copper.

1.4.3.7 Earth Resistivity Modeling

Soil resistivity measurements will be taken at each substation location. The Werner 4-point method described in IEEE Standard 80 shall be followed. A minimum of two layer soil model will be developed using an industry standard approved computer earthing analysis software to develop the soil model. Due to the limitation of IEEE Standard 80 using the uniform soil model, the industry standard computer earthing model shall be developed following IEEE standard 80 guidelines.

1.4.4 Medium Voltage Cable

1.4.4.1 Standards

The equipment supplied shall conform to the latest edition of the appropriate IEC specifications or other recognized international standards. In particular:

IEC 60028	Standard resistance for copper
IEC 60060	High voltage test techniques
IEC 60071	Insulation co-ordination
IEC 60228	Conductors of insulated cables

IEC 60229	Tests on cable oversheaths
IEC 60230	Impulse tests on cables and accessories
IEC 60287	Electric Cables - Calculation of the current rating
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30kV
IEC 60811	Common test methods for insulating and sheathing materials of electric cables
IEC 60885	Electrical test methods for electric cables
VDE 0278	Power cable accessories with rated voltages up to 30kV
ASTM D2303	Inclined plane non-tracking test method.

1.4.4.2 Inspection and Testing

Tests shall be performed at the manufacturer's works in accordance with the relevant IEC standards supplemented by the specific requirements indicated below.

The tests will be divided into the following categories:

Routine and Special Tests

- Check for compliance with specifications herein and with the scheduled quantities.
- Conductor electrical resistance measurements
- Partial discharge test
- High-voltage test
- Conductor examination
- Check of dimensions
- Electrical test for 4 hours
- Hot set test

Type Tests
The Employer may call for type tests to be carried out at the Manufacturer's Works and witnessed by the Employer or representative. Such test would be on random samples at the discretion of the Employer and failure to meet the conditions of test could result in the rejection of a complete batch of cable.

When such tests are called for they will comprise the following:

- Partial discharge test
- Bending test, plus partial discharge test
- Dielectric power factor as function of voltage and capacitance measurement, and as a function of temperature
- Heating cycle test plus partial discharge test
- Impulse withstand test, followed by power frequency voltage test
- High voltage ac test
- Non-electrical tests as stated in IEC 60502.

After Installation Test
When the installation of the cable and its accessories has been completed, a voltage test will be made by the Employer with a dc voltage of 70% x 2.4 times the rated power-frequency voltage for which the cable is designed, applied for 15 minutes.

1.4.4.3 MV Three Core XLPE Insulated Cables

General
Three core 11.5/20 (24)kV 185mm^2 aluminum conductor, cross-linked polyethylene (XLPE) insulated, PVC sheathed cable shall be supplied for connecting the indoor 20kV switchgear to the outgoing 20kV distribution circuits.

Construction Details
The cable shall comprise three core stranded aluminum conductor, each with semi-conducting conductor shielding, cross-linked polyethylene insulation, semi-conductor shielding and copper tape screen. The three cores shall be laid up to form a circular cross-section using PVC fillers and bound overall with polyester tapes. The cables shall be bedded with extruded PVC, armored with steel wire and sheathed overall with black PVC.

Conductors
The cores shall be circular stranded conductor comprising 240mm^2 aluminum wires.

Conductor Screen
Conductor shielding shall be extruded semi-conductor 1mm thick.

Insulation
Insulation shall comprise cross-linked thermosetting polyethylene and shall be nominally 5.5mm thick.

Core Identification
The cores shall be identified by the numbers 1, 2 and 3 printed on the outer extruded semi-conductor.

Insulation Screen
The insulation screen shall consist of a semi-conducting part in combination with a metallic part. The semi-conducting screen shall be extruded semi-conducting of minimum thickness 0.8mm applied in intimate contact with the insulation.

The metallic screen shall be plain annealed copper tape helically applied directly over the semi-conducting screen.

Laying Up
The screened conductors of the three cores shall be laid up together with PVC fillers to form a circular cross section and bound overall with two polyester tapes.

Armor
The armor shall consist of 0.85mm diameter steel wires. The armor shall be applied over PVC bedding.

Outer Sheath
The outer sheath shall comprise 3.5mm thick black extruded PVC, containing a termite repellent additive.

Manufacturer's Identification
'20,000 VOLTS' the year of manufacture, the Manufacturer's identification and the core cross-section shall be embossed in the cable sheath. A sequential number shall be embossed at meter intervals to facilitate cable measurements.

Current Carrying Capacity
The cables may be laid directly in the soil, or run in air or ducts, with air and ground temperatures as prevailing in Afghanistan.

The current capacity shall be stated by the Bidder for conditions detailed in Table 2.4.9.

Table 1.4.9 MV Three Core Cable Capacity - Environmental Conditions

MV Three Core Cable Capacity - Environmental Conditions	
Ground temperature	25°C
Maximum conductor temperature	90°C
Thermal resistivity of soil	1.2°C m/W
Depth of burial	0.8m

In addition, the Bidder shall advise rating/de-rating factors for variations in the above conditions.

1.4.4.4 MV Single Core XLPE Insulated Cables

General
Single core 11.5/20 (24)kV 240mm^2 aluminum conductor, cross-linked polyethylene (XLPE) insulated, PVC sheathed cables shall be supplied for connecting the secondary of the power transformer to the 20kV incoming circuit breaker on the indoor 20kV switchgear.

Construction Details
The cables shall comprise stranded aluminum conductors with semi-conducting conductor shielding, cross-linked polyethylene insulation, semi-conductor shielding, copper wire screen, and sheathed overall with black PVC.

Conductors
The core shall be circular stranded conductor comprising 240mm^2 aluminum wires.

Conductor Screen
Conductor shielding shall be extruded semi-conductor minimum of 1mm thick.

Insulation
Insulation shall comprise cross-linked thermosetting polyethylene and shall be nominally 5.5mm thick.

Insulation Screen
The insulation screen shall consist of a semi-conducting part in combination with a metallic part.

The semi-conducting screen shall be extruded semi-conducting of minimum thickness 0.8mm applied in intimate contact with the insulation.

The metallic screen shall be plain annealed copper wire helically applied directly over the semi-conducting screen.

The metallic screen shall be able to withstand a fault current of 25kA for one second.

Outer Sheath
The outer sheath shall comprise 2.0mm thick black extruded PVC, containing a termite repellent additive.

Manufacturer's Identification
'20,000 VOLTS' the year of manufacture, and the Manufacturer's identification shall be embossed in the cable sheath. A sequential number shall be embossed at meter intervals to facilitate cable measurements.

Current Carrying Capacity
The cables may be run in air or ducts, with air temperatures as prevailing in Afghanistan.

The current capacity shall be stated by the Bidder for the conditions detailed in Table 2.4.10.

Table 1.4.10 MV Single Core Cable Capacity - Environmental Conditions

MV Single Core Cable Capacity - Environmental Conditions	
Ground temperature	25°C
Maximum conductor temperature	90°C
Thermal resistivity of soil	1.2°C m/W
Depth of burial	0.8m

In addition, the Bidder shall advise rating/de-rating factors for variations in the above conditions.

1.4.4.5 MV Terminating Kits

General
All high voltage terminations and joints shall be of a heat recoverable polymeric 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, equivalent to the cable being terminated.

The Contractor shall submit at bidding, and supply with contract, complete illustrated instructions describing the methods for terminating or jointing the cable.

Each terminating or jointing kit shall be in a separate package and a list of materials indicating quantities and weights in the kit, and an illustrated instruction sheet shall be included in the package.

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

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

The termination or joint shall be capable of tolerating any variances in the manufactured dimensions of the cable such as oval, out of round, sectored or oversize cable cores. The termination shall be capable of immediate energization once all components have been installed. The terminating or jointing materials shall not be subject to storage limitations such as controlled temperature or humidity restrictions, nor have shelf life limitations.

Standards
The equipment supplied shall conform to the latest edition of the appropriate IEC specifications or other recognized international standards. In particular:

- IEC 60060 High voltage test techniques
- IEC 60071 Insulation co-ordination

- IEC 60230 Impulse tests on cables and accessories
- VDE 0278 Power cable accessories with rated voltages up to 30kV.

Inspection and Testing
Tests shall be performed at the manufacturer's works in accordance with the relevant IEC standards supplemented by the specific requirements indicated below.

Routine and Special Tests
Check for compliance with specifications herein and with the scheduled quantities.

Type Tests
The Employer may call for type tests to be carried out at the Manufacturer's Works and witnessed by the Employer or representative. Such test would be on random samples at the discretion of the Employer and failure to meet the conditions of test could result in the rejection of a complete batch of cable.

When such tests are called for they will comprise the following:

- AC voltage withstand test
- Loading cycle tests
- Partial discharge test
- Impulse voltage withstand test
- Thermal short circuit test
- DC voltage withstand test
- Humidity test (only for terminations)
- Non-tracking tests.
- Termination Materials

Termination materials for MV power cables shall provide for high permittivity electrical stress control, non-tracking exterior surfaces and complete environmental sealing. Electrical stresses shall be controlled by a high permittivity, high resistivity, heat shrinkable polymeric tubing.

Heat recoverable polymeric materials and terminations shall comply with requirements of IEC 60502, IEC 60446 Appendix C, IEC 60060 sub clause 3.3, IEC 60071, IEC 60507 Section 3, and VDE 0278.

The materials and the completed terminations shall be for the appropriate type of service, size and voltage and shall include ferrules, lugs and other materials necessary for the terminating of the conductor and clamps, braid, etc. necessary for the terminating of screen and sheath for earth continuity.

All heat shrinkable polymeric tubing and pre-molded materials shall be ultra violet stable, non-tracking (per ASTM D2303) and suitable for operation in the presence of severe external contamination and environmental pollution.

Three-core cable terminations shall use a heat shrinkable polymeric molded cable breakout to provide mechanical stress relief and sealing.

The entire termination or joint shall be environmentally sealed and capable of preventing the ingress of external moisture and contamination. Internal terminations shall fully insulate all bare metal adjacent to the termination.

MV Termination Kits
Termination kits shall be supplied for terminating the specified aluminum 20kV XLPE single and three core cables onto switchgear and transformer terminals. All 20kV terminations shall be of the fully shrouded type so that the terminations, when made, fully insulate the cable lug and the equipment terminal.

The termination kits shall comprise:

- Compression lugs
- Sealant tape
- Non-tracking lug sealing sleeve
- Non-tracking weather resistant exterior
- Stress control equipment
- Non-tracking three-way shed
- Non-tracking cable breakout
- Copper braid for earthing onto screen
- Jointing instructions
- All other items necessary to complete the kits

1.4.4.6 Tools

The following tools of well-proven design and performance shall be supplied for cable terminating and jointing and shall be handed over to the Employer at the end of the contract.

- Foot operated hydraulic 12 ton compressor complete with dies to fit all compression terminals and connectors as supplied with the terminating kits. One tool shall be suitable for all die sizes, and shall be complete with:
  - Recommended kit of spares, each kit to include at least three sets of all seals and other items required during normal servicing
  - Pressure test gauge including test blank dies
  - Complete set of repair and service tools
  - Maintenance and operating instructions
  - Service and repair manual
  - Strong metal box for protection of hydraulic compressor unit when not in use.
- Hand operated hydraulic compression tool
- Shear type cable cutters for cutting maximum cable size of 3 core 20kV 240mm^2 cable
- Pencilling tool for XLPE insulation for shaping all cables specified
- Electric hot air blower suitable for shrinking heat recoverable jointing and terminating materials, 230V AC
- Gas hot air blower suitable for shrinking heat recoverable jointing terminating materials including hoses, regulator and 3kg gas bottle

1.4.5 Cable Racks

A sufficient number of fittings, rack-joints and angles shall be included in the supply. Medium voltage, low voltage and control cables shall each be laid on separate cable racks. Cable racks and suspension fittings shall be dimensioned for a distributed load of at least 150kg/m.

Cable racks, accessories and suspension fittings shall be hot dip galvanized after manufacturing or be made of aluminum. Accessories shall be designed so pulling of cables can be done without damage. Diversion plates shall be used at junctions.

The cable racks shall be erected in a way so cables can be laid without threading. The distance between a horizontal rack and the wall shall exceed 50mm to allow cables to be pulled down between the rack and the wall. Sharp edges, screw-tips, etc., shall be removed from the rack before cable pulling. Expansion bolts used for suspension fittings shall have a diameter of at least 6mm.

The cable racks shall be connected to the station earth wire system. An earth wire laid along the rack shall be tied underneath to the rack at every second step.

1.4.6 Marking of Equipment

All main parts of the plant, including towers, gantries, busbars, apparatus, etc. shall be equipped with designation labels. All switchgear, distribution boards and control gear and units thereof, components mounted therein and wiring and cables, shall be labeled and marked according to IEC. The purpose of the labeling and marking is to facilitate the identification of switchgear and control gear and parts thereof and their relation to the relevant technical documentation in order to facilitate a rational and simple manner of installation, operation, troubleshooting, maintenance and repair.

All apparatus in the outdoor switchgear shall be labeled. Labels shall normally be placed adjacent to the middle phase. The main transformers shall be labeled with phase designations on all primary, secondary and tertiary bushings.

Designation system for text on designation labels will be provided by the Employer. Text on warning labels shall be approved by the Employer. The text on operational and safety labels shall be in both the English and the Afghan language.

Labels for outdoor use shall be of enameled sheet metal. Labels that are protected from solar radiation shall be made of fiberglass-reinforced polyester with embedded color layers. Labels shall be fixed by stainless steel screws or rivets. Enameled labels shall have stainless steel hole reinforcements.

Labels shall be white with red text and red frames. Phase designation labels shall be respectively colored red, yellow and blue for phases L1(R)-L2(Y)-L3(B). Sizes shall be chosen with regard to label location. Phase markings shall have the same height as designation labels at the same location, and shall be square.

Warning labels shall have a lightning bolt symbol in red at both ends. Warning labels shall be mounted on all dangerous parts of the installation. This means:

- A general warning label on low voltage distribution boards
- Special warnings shall be applied on all cubicles where back voltage can appear after switches are opened
- General warning labels outside all fences, gates or walls surrounding the substations. These shall be applied every 50 m along fences and walls. Completion with labels stating prohibitions against entrance, photographing, etc., shall be done at the Employer's request
- Labeling, as is deemed necessary to prevent dangers arising from mal-operation of equipment.

Inside the entrance doors to each building in the substation a large sign of poster type, of durable design, shall be set up. It shall show steps and methods to be taken and used in case of electrical accidents where persons are hurt, i.e. first aid principles and how to proceed.

Fire extinguishers shall be supplied and shall have a clearly readable sign applied to the wall above them, with notices about type and size.

In addition to the above, labeling and marking shall apply as follows:

A. Each switchboard and control board shall have one label stating the make, the maker's identification data and rates, insulation voltage class and one label identifying the board in the plant.
B. Each unit of switchgear or control gear (such as a cell, panel, cubicle or box as well as remote located switching and control devices) shall have a label identifying the unit and stating its purpose in the plant. The latter information is in more complicated cases suitably given in a mimic diagram.
C. All apparatus or units of apparatus in the panels, cells, etc., shall have labels or markings identifying the apparatus or units thereof (normally the relevant apparatus designations used in the technical documents for the switchgear or control gear). In some cases this marking shall be completed with function marking in plain text. Apparatus labels shall be affixed by means of screw or reverts on the framework, so they remain in place when the apparatus is dismounted or changed.
D. All terminals of apparatus or apparatus units shall be clearly marked. However, this marking may be omitted when the design and arrangement of the apparatus are such that a marking is obviously unnecessary.
E. All electronic printed circuit boards shall have type marking. The electronic cubicles shall have item marking for each circuit board for identification of the circuit board in the schematic diagram.
F. All instruments, indicating devices and control devices shall have identification marking in plain text or simple symbols or colors. Control devices shall in addition have marking of control positions in plain text, simple symbols or colors.
G. Control cable terminals and, for small load circuits, also power terminals, shall be clearly marked for identification. The marking system shall be logically built up from letter and/or figures in one system consistently used within the switchgear or control gear.
H. Internal wiring within switchgear, control gear or apparatus units shall have all wire ends marked, the marking to include as a minimum the same marking as has the terminal to which the wire end is connected. The marking shall be carried out with sleeves or similar. Tape is not permitted. Current and voltage circuits shall also have phase marking and, where necessary, polarity marking. Protective earth wires shall be marked with green-and-yellow.
I. Cables connected to switchgear, control gear, external apparatus, etc., shall be marked with cable numbers according to the cable list and core number according to the external connection diagram. In addition, all cable cores shall have the same marking as the terminals to which cores are connected. Marking with glued tape is not permitted. The marking shall be indicated with ferrules. The ferrules shall be of white insulated material and be provided with a glossy finish preventing adhesion and dirt. They shall be clearly and durably marked in black and shall not be affected by damp or oil.
J. Trenches with buried cables shall be marked with labels on walls where applicable or with labels on posts with one set up at each end of a road crossing, one set up for every point of change of direction of a cable trench, and one set up for each twentieth (20) meter of a cable trench. The cables shall be provided with warning tapes along all the trenches.
K. All labels shall be of plastic or metal indoors and of enameled metal outdoors, and shall have the text or symbol engraved. Text and symbols shall be of dark color and the surface shall be light. All labels shall be permanently fixed to the switchboard and apparatus. Glued labels and marking tape are not acceptable.

Some of the above required markings and labeling may, subject to the Employer approval, be combined or omitted for uncomplicated parts of the equipment.

1.4.7 Optical Fiber Cables

Outdoor Optical Fiber Cable
Single mode outdoor optical fiber cable is required to connect the end of the OPGW cable at or near the terminal transmission tower to a fiber optic patch panel in the substation/switching station control room. In addition, outdoor single mode and/or multi mode cable shall be used between buildings if there is more than one operational building on a site.

Outdoor optical fiber shall be of loose tube, gel filled construction and shall be installed in HDPE cable ducts or direct buried in plastic conduit. The cable shall have a non-metallic central core sheathed with black polyethylene. An armored layer shall surround the inner sheath made up of corrugated steel or aluminum tape at least 0.2mm thick followed by an outer polyethylene sheath.

Indoor Optical Fiber Cable
Single mode and/or multi mode indoor optical fiber cable will be used to interconnect equipment within the control buildings. Indoor optical fiber cable shall be of tight buffered construction and shall be installed in cable ducts or on cable ladder. The cable shall have a non-metallic central core sheathed with black polyethylene. A non-metallic strength layer shall surround the inner sheath followed by an outer polyethylene sheath.

Common Requirements for Optical Fiber Cables:

Number of fibers:	at least 12, but not less than the number of cores in any other cable to which the cable is joined
Spare fibers:	at least 4 for cables with up to 12 fibers and at least 6 for cables with over 12 fibers (counted after the system is commissioned)
Standard:	ITU-T G.652
Max. tensile strength:	≥ 2700N
Cladding non-circularity:	≤ 2%
Covering material:	Polyethylene capable of resisting insects and rodents
Water proof capacity:	according to IEC 60794-1-F 5
Operating environment:	according to TCN- 68-149:1995
Environment temperature:	-5 to +650C

Single mode optical fibers shall be designed to optimize transmission of light at both the 1,310nm and 1,550nm wavelengths. The core/cladding diameters shall be 9/125μm.

Multi mode optical fibers shall be designed to optimize transmission of light at the 850nm wavelength. The core/cladding diameters shall be 62.5/125μm.

Patch Leads/Pigtails
Fiber patch leads shall be used to connect between equipment within a cubicle, and may also be used between cubicles up to a distance of 10m. For lengths greater than this, indoor optical fiber cable shall be used with suitable breakout termination enclosures. When run externally between cubicles, the patch leads shall be suitably protected by being run in plastic conduit. Patch leads shall be Kevlar® (or aramide) reinforced and plastic coated optical fiber conforming to ITU-T Recommendation G.652, and be color coded depending on function (data, telecom, CCTV, protection etc.).

Where a termination enclosure is installed, all fibers of all cables are to be terminated on "pigtails" (or break-out cable) with a minimum length of 1m. The pigtail shall be a Kevlar® (or aramide) reinforced and plastic coated optical fiber conforming to ITU-T Recommendation G.652.

1.4.7.1 Fiber Optic Accessories

Junction (Splicing) Box
Outdoor junction boxes shall be provided as required. These junction boxes shall be used to house the fiber core splices which connect the trunk cable (e.g. OPGW) to the outdoor intermediate optical cable leading to the patch panel in the control room.

A fiber optic cable junction box shall provide the following:

- It shall support, organize, and protect the optical fibers and the fiber splices whilst ensuring that the optical
- fiber minimum-bending radius is not exceeded
- The splice tray shall not have any sharp edges or protrusions that may damage the optical fiber cable
- It shall provide entry for all cables
- Include number tags for tube and fiber identification
- The junction box shall be rated to IP65 in accordance with IEC 60529
- The enclosure shall be lockable.

The Junction box shall be mounted on a wall or pedestal at a conveniently accessible height.

Termination Patch Panels and Breakout Enclosures
Fiber optic cable patch panels shall be provided in the control room to patch the external optical fiber cable cores to the appropriate communications devices in the station.

Breakout enclosures shall be provided in cubicles to transition between optical fiber cable and individual fiber tails.

Sufficient connectors for all incoming and outgoing fibers, including spares, shall be provided in each enclosure.

A fiber optic cable termination patch panel shall provide the following:

- It shall support, organize, and protect the optical fibers and the fiber splices whilst ensuring that the optical fiber minimum-bending radius is not exceeded
- The splice tray shall not have any sharp edges or protrusions that may damage the optical fiber cable
- It shall provide entry for all cables
- Include number tags for tube and fiber identification
- It shall provide mounting positions for the bulkhead FC/PC type connectors on which the cable will be terminated
- It shall allow patching of fibers.

The patch panel shall have a fiber capacity equal to the total number of fibers (connected and spares) for all cables to be connected. Patch panels shall be designed for 19-inch rack mounting within a standard equipment cabinet.

All unused couplings shall have protective dust covers. The patch area shall be accessible behind a door or removable cover.

Sufficient factory manufactured patch cords with suitable color coding shall be provided.

Fiber Connectors
All optical connectors shall be field installable and perfectly matched to the cable used. The connectors shall provide tight fitting termination to the cladding and buffer coating. Epoxy based or "hot melt" adhesives shall be used to bond the fiber and buffer to the connector ferrule and body prior to polishing the end face. No dry termination or "quick crimp" connectors are allowed.

After termination with connectors, the fiber ends must be visually inspected at a magnification of not less than 100 to check for cracks or pits in the end face of the fiber. If any irregularities found cannot be removed by further polishing, the entire process must be redone by cutting off and disposing the connector body.

Connectors shall have a maximum allowable connection loss of 0.3dB per mated pair, as measured per EA.-455-34, without use of index-matching gel (dry interfaces only). Single mode connectors shall be capable of field installation on 9/125 micron fibers with 900µm (OD) buffers.

Communications equipment shall use the industry standard FC/PC type connector, designed for single mode or multimode tolerances, and shall meet or exceed the applicable provisions of EA.-455-5, 455-2A, and 455-34, and shall be capable of 100 repeated matings with a maximum loss increase of 0.1dB. Substation equipment shall use either FC/PC type or ST type connectors. Connectors shall incorporate a key-way design and shall have a zirconium ceramic ferrule.

Connector bodies and couplings shall be made of corrosion-resistant and oxidation-resistant materials, such as nickel plated zinc, designed to operate in humid environments without degradation of surface finishes.

Where a termination enclosure is installed, all fibers of all cables are to be terminated on "pigtails" with a minimum length of 1m. The connector shall be inserted on the cable side of the bulkhead (feed-through) connector in the termination enclosure. All connectors shall be supplied with a removable cap to protect against moisture and dust ingress when not connected.

1.4.8 Control, Relay and Auxiliary Power Equipment

1.4.8.1 Control, Relay and Auxiliary General

The control panel in the control building shall include control and indication of all 220kV and 20kV circuit breakers and disconnectors. The control panel shall be integrated with the relay panel. The transformer control and protection and OLTC panels shall include control and indication of the power transformers. The control switches for the circuit breakers and disconnectors and indicating instruments shall be installed directly on the front of the control panel.

The panel front shall also include a mimic diagram, reflecting the actual layout of the complete 220kV and 20kV switchgear. The mimic diagram shall have different colors for different voltages and symbols for the main apparatus.

1.4.8.2 Design Data

Voltages shall be as indicated in Table 2.4.11

Table 1.4.11 Control, Relay, and Auxiliary Voltages

Control, Relay, and Auxiliary Voltages	
Auxiliary power	400/230V AC three-phase, 4/5 wire with system earthing TN-C-S
General auxiliary voltage supply	220V DC2-wire insulated system

Control, Relay, and Auxiliary Voltages	
Tolerances	are +10% - 15% measured at the consuming objects

1.4.8.3 Control, Relay, Metering and Alarm Boards

The boards shall be made of sheet steel of at least 2 mm thickness and be of vermin-proof design IP 43 according to IEC 60529. Boards shall be wired at the Contractor's workshop before delivery to Site. To facilitate transportation, the boards should be assembled in convenient sections before delivery.

All boards shall have a maximum height of 2,300mm. The boards shall be equipped with a master key-locking system. Each board shall have lighting that is switched on when the door of the cubicle is opened. Humidity controlled heaters shall be provided.

Terminal blocks for cable termination shall be mounted on the sides inside the boards and all cable entrances be supplied with glands. Terminal blocks for CT circuits shall be equipped with testing plugs for commissioning purpose. All boards shall be connected to the general earthing system. Each board shall be labeled.

1.4.8.4 Operation and Indication, Control Systems

General
All control and indication circuits shall be designed for 220V DC. Fuses for various DC circuits for control, relay protection, indication, etc., shall be mounted in separate boards. Each circuit shall be supervised by voltage relays giving alarm in case of lost voltage or tripped fuse.

Interlocking System
A complete interlocking system shall be incorporated in the operating circuits for motor-operated disconnectors. The purpose of the interlocking system is to prevent opening of disconnectors while circuits are still loaded. An earth switch shall be mechanically interlocked to the disconnector to which it is attached.

Indicating Instruments
The indication instruments shall have dimensions 96 mm x 96 mm and be flush-mounted. The indication instruments shall be of angle type with 240° scales, indication errors shall not exceed ±1.5% of the full-scale value. The instrument scales shall have a white background and the same design of figures and gradation. The indicated values shall be given directly without constants such as x10 and the like. Panel instruments shall be provided as indicated in Table 2.4.12.

Table 1.4.12 Panel Instrumentation

Panel	220kV	20kV
Line/Feeder Bay	3 x V 3 x I	3 x I 3 x PF 3 phase MW with ± scale 3 phase MVAr
Transformer Bay	3 x I 3 x PF 3 phase MW 3 phase MVAr	3 x I 3 x PF 3 phase MW 3 phase MVAr
Busbar Bay	3 x V	2 x 3 x V

1.4.8.5 Alarm Equipment

An alarm annunciator shall audibly and visually identify the source and type of alarm. There is no requirement for a remote fault signal system.

1.4.8.6 Relay Protection

The proposed relay protection is listed in Table 2.4.13. The Contractor shall add all additional protection as necessary for their nominated plant and equipment:

Table 1.4.13 Proposed Relay Protection

Proposed Relay Protection	
220kV Feeder	Duplicate numerical distance protection scheme. Each protection scheme shall incorporate directional and non-directional over current and earth fault protection, circuit breaker fail protection, auto reclose, fault location and transient recorder functionality. The relays supplied for the duplicate relay protection scheme shall not be supplied by the same manufacturer. The distance scheme design will be carrier signal assisted and intertrip signaling provided as required.
220kV Busbar	Differential protection – high impedance, with two main zones and one check zone
220/20kV Transformer	One multi-function HV over current relay One multi-function LV over current relay One multi-function differential transformer mounted protection including, Winding and oil temperature low level alarm, Winding and oil temperature high level trip, Oil level alarm, Gas relay (Buchholz relay), pressure relay
20kV Feeder	Multi-function feeder over current, earth fault and over current relay
20kV Busbar	Over-voltage and under-voltage protection.

The relay protection shall consist of numerical type relays with self-supervision. Each relay protection shall have test facilities of a type enabling testing of the entire relay combination while the protected part is in service. It shall be possible to block all tripping impulses by means of switches.

The setting ranges of the relays shall be selected to fit into the existing selectivity plan. All ranges will be settled at a later stage. All relay protection shall have individual indicating devices and be designed for easy resetting both by local and remote operation.

Possible influence from induced voltage in a control cable shall be taken into account, e.g. introducing barrier relays between relay protection and outgoing cables to switchgear, etc. Tripping outputs shall be of high-speed type. Tripping contacts shall be of heavy-duty design to obtain required contact duty for breaking.

1.4.8.7 Metering Equipment

Energy meters shall be provided as indicated in Table 2.4.14.

Table 1.4.14 Energy Meters

Panel	220kV	20kV
Line/feeder Bay	kWh delivered, kWh received, Four-quadrant kVArh With data access facilities and pulse output, class 0.2	kWh delivered, Four-quadrant kVArh, With data access facilities and pulse output, class 0.2
Transformer Bay	kWh delivered, kWh received Four-quadrant kVArhWith data access facilities and pulse output, class0.2 (on the 20kV side of 220/20kV transformer)	

Meters installed for monitoring of energy consumption shall be kWh delivered and kWh received for kWh (MWh) and four quadrant for kVArh (MVArh). Accuracy class for meters shall be 0.2 for active energy and 0.5 minimum for reactive energy. Meters shall have the facility for remote interrogation via modem and the SCADA/CSCS and shall provide pulsed outputs to the metering data processors. Two data processors (main and backup) shall be supplied for recording and totaling metering pulses, with programmable 20 or 30-minute printout facilities and 20 inputs minimum for each processor.

Each meter shall be provided with a testing terminal block enabling the meter to be switched off in a simple manner.

1.4.8.8 Control Cables and Earth Wires for Control Systems

Control Cables
Control cables shall be of multi-core type, PVC insulated, with screen and copper conductors. Cables shall be termite-proof in an approved manner. All cables shall be laid in plastic pipes of a suitable size and standard. Medium voltage, low voltage and control cables shall be laid in separate pipes.

For low level signals, e.g. outputs from transducers, cables shall have conductors of tin coated stranded copper wires and screen of aluminum foil and copper wires (Electronic cables). Cables containing more than 10 cores shall be so dimensioned that at least 25% of the cores will serve as standby cores.

The cables shall comply with design criteria detailed in Table 2.4.15.

Table 1.4.15 Design Criteria - Control and Electronic Cables

Cable	Control	Electronic
Nominal voltage	230V	0V - 220V
Maximum current	10A	2A
Insulation level	0.6/1kV	0.6/1kV
Frequency	DC or 50Hz	0Hz-1000Hz

As a protective jacket the cable shall have an extruded sheath of grey or white PVC in waterproof color marked with:

- Name of manufacturer
- Year of manufacture
- Cross-section area of phase-conductors and number of cores.

The cables shall be delivered in full lengths and, consequently, no joints are permitted. Cable terminations are normally not needed for these types of cables, however all cable terminations shall be provided with cable glands.

Earth Wires for Control Systems
All control boards, relay boards, marshalling boxes, transformers, apparatus, etc., shall be connected to the main earthing system.

An earth bar shall be installed in the control building for transition of earth wires in the different rooms. The earth wires shall be separated from control cables, etc. The earth wire system shall be of stranded copper wire designed for the maximum prospective fault current.

Secondary Circuits

Auxiliary cables shall be PVC-insulated for a test voltage of 2kV, 50Hz and shall be screened or metal-sheathed. The conductors, screens and metal sheaths shall be made of copper.

The following minimum areas shall be applicable:

Current circuits for protection relays 2.5mm^2
Instrument, voltage and control circuits 1.5mm^2

The auxiliary cables shall be designed for a maximum voltage drop from voltage transformers to instrument and meters of 0.1%, and to relays 1.0%. Total burden shall not load the secondary winding of voltage transformer more than 75% of rated burden. Total burden shall load the secondary winding of a current transformer between 25% and 75% of rated burden.

The screen of control cables in connection with the outdoor switchgear shall generally be earthed at both ends. All other cables shall generally be earthed at one end only. In case of earthing at one end only, the location of the earthing shall be indicated on the diagrams.

Auxiliary conductors in apparatus cubicles such as control and relay cubicles, etc. shall be stranded PVC cables with a minimum area of 1.5mm^2.

Conductors within cubicles and between terminal blocks and apparatus shall be laid in plastic ducts or covered with plastic bands. Conductor ends not connected to compression-type terminal blocks shall be provided with approved claw washers, which neatly retain all strands. Wiring shall be arranged to give easy access to the terminal of relays and other apparatus. All jointing and tying of wires shall be carried out only at the terminal points.

Spare cores, if any, shall be connected to terminal blocks in cubicles and marshalling boxes.

Boards and Marshalling Boxes for Control Systems

Boards and marshalling boxes shall be made of steel and designed for adverse conditions and be vermin-proof. The doors shall be of the lift-off and hinged type. Boards and boxes for indoor installation shall fulfill Degree of Protection IP 43 according to IEC 60529. Boards and boxes for outdoor installation shall fulfill Degree of Protection IP 54.

The cables shall be mounted so that they are protected against damage and vibrations. The cables shall enter through glands, which shall properly be above the gland plate to prevent moisture from entering the cables.

Boards and marshalling boxes located outdoors or in damp surroundings shall have ventilation and drainage openings as well as a heater for connection to 230V, 50Hz. They shall also be provided with lighting equipment. Boards and marshalling boxes and equipment installed in them shall be of satisfactory corrosion-proof design. All box openings shall be screened for protection against vermin, and be so arranged that entry of water is prevented. For screening of the holes, netting with at least one mesh per mm shall be used.

All marshalling boxes shall be placed at normal working height and shall be sufficiently spacious to facilitate the connection of leads. They shall be so designed as to make markings easily legible.

Not more than two cores shall be connected to each side of a terminal block. Each board and box, etc., shall be connected to the station earth system by a copper wire with a minimum area of 25mm^2.

Terminal Blocks

All terminal blocks shall be equipped with visible isolating arrangements for testing purposes. They shall be provided with sockets for banana plugs, at both sides. The terminal blocks shall be insulated for 500V and shall have provisions for marking. The terminal blocks shall be mounted to give easy access to wires, terminations and ferrules. The terminal blocks shall also give a clear view of the arrangement of the cable tails.

Terminals connected to 400/230V shall be properly protected and separated from control circuits.

1.4.8.9 Auxiliary Power Transformers

General

The auxiliary power transformers shall be 3 phase, oil immersed. The design shall comply with IEC 60076 and be rated in accordance with Table 2.4.16.

Table 1.4.16 Auxiliary Power Transformers

Auxiliary Power Transformers	
Location	All Substations
Rated power	250kVA
Rated frequency	50Hz
Rated voltage	20 ± 2 x 2.5 %/0.4kV
Impedance voltage	4%
Vector Group	Dyn11
Cooling	ONAN
Design fault levels, HV-winding	500MVA

The auxiliary power transformers shall be of a suitable type for service under the specified ambient conditions.

The transformers shall be capable of withstanding continuous operation at the rated power and at a voltage 10% higher than the rated voltage without causing dangerously high temperatures or abnormal vibration.

The transformers shall be designed with cable entry boxes for direct cable connection on the medium voltage and low voltage side. Oil or compound filled cable boxes are not permitted.

Oil

The oil shall contain at least 0.3 per cent by weight oxidation inhibitor of type diterbutyl paracresol (DBPC) according to IEC 60296. The oil shall not contain PCBs. If oil samples taken from the transformer on delivery contain 2ppm or more of PCB, the Employer has the right to refuse the delivery of the transformer.

Accessories

The following accessories shall be provided for the transformer:

- Bushings for HV side
- Cable entrance boxes for LV side
- Marshalling box including terminal blocks for connection of external cables to the transformer accessories

- Oil temperature indicator
- Valves for filling and draining the oil
- Lifting devices such as eyes or hooks for lifting the complete transformer with oil and for lifting the coil and core assembly alone.

1.4.8.10 Auxiliary Power Equipment

Motors
Electrical motors shall fulfill the following requirements:

- Insulation Class F
- Enclosure Degree of Protection IP 54
- Cooling design IC 4

They shall have protected drainage holes, and be capable of operating continuously under equal service conditions without exceeding the specified temperature rises. All motors required to operate in damp or humid conditions or located outdoors shall be supplied with electrical heating equipment in order to protect the windings against moisture.

Low Voltage Boards
The requirements for boards are where applicable also valid for boxes for separately mounted apparatus. Boxes outdoors shall fulfill Degree of Protection IP 54 according to IEC 60529 and have thermostat-controlled heaters, ventilation and drainage.

All cables shall be connected to the boards with terminal blocks of approved type located near the cable entry. Cables with large cross-section areas are permitted to be connected directly to the apparatus.

All auxiliary circuits shall be connected to terminals with isolating arrangements having 4 mm banana plug sockets on both sides. All boards shall have 10% spare terminals for power circuits and 10% for auxiliary circuits. All distribution boards shall have 20% spare space for future extension.

The boards shall be complete with terminal block marking, full set of circuit breakers, switches and fuses as well as with other components required. The boards shall be designed for erection on wall without rear access. The operation devices for switches and control switches shall be operated from the front of the board without the doors being opened. The expanding gases developed in case of a short-circuit shall be directed in a safe direction in order to prevent injury to persons being near the board.

AC Boards
Boards for 400 V AC shall be of metal-enclosed of panel type and vermin-proof designed, Degree of Protection shall be IP 43 according to IEC 60529.

The boards shall have Cu busbars for phases, neutral (N) and protective earth (PE). The neutral busbar shall also have full insulation against earth and be connected to earth with one link in the board only (power system TN-C-S). The earth busbar shall preferably be located near the outgoing cable terminals.

DC Boards
Main and battery boards for 220 V DC shall be plastic-enclosed of panel type and vermin proof designed, degree of protection shall be IP 43 according to IEC 60529.

Distribution boards for DC may be metal-enclosed, but shall fulfill all requirements as for the main board. The battery boards shall have separate enclosures and shall be mounted as near the batteries as possible.

LOW VOLTAGE APPARATUS
Circuit Breakers
Circuit breakers shall be capable of interrupting the available short-circuit energy. Miniature circuit breakers shall be used for all loads 430V / 80A and below.

Air Break Switches
The low voltage switches for the AC boards shall be of Utilization Category AC 23 and DC 23 respectively. The switches shall be front-operated and have distinct ON-OFF markings and have provision for locking. Switches on the main boards shall be of plug-in type.

Switch Disconnectors
Switch disconnectors shall be of utilization category AC 23 (DC 23). Switch disconnectors shall be operated from the front of the box and have distinct OFF-ON markings with possibility for locking with padlock in OFF position.

Fuses
Power fuses shall be of blade type according to IEC 60269 - 2A Section I. Fuses maximum 25A may be of screw type DII (IEC 60341). The fuses shall have a visible indication device. For small apparatuses, miniature fuses 5x20mm (IEC 60127) may be used.

Control Switches
Control switches shall be designed for 10A and be marked OFF-AUTO-ON, etc. Control switches shall be operated from the front of the cubicles.

Current Transformers
Current transformers shall be of the dry type for mounting on busbars or cores. Secondary current shall be 1A.

Measuring Instruments
Voltmeters and ammeters shall have dimensions 96mm x 96mm and be flush-mounted. The indication instruments shall be of square type with 240° scales, indication errors shall not exceed ±1.5% of the full-scale value. The instrument scales shall have a white background and the same design of figures and gradation. The indicated values shall be given directly without constants.

1.4.8.11 50kVA Back-up Diesel Generator

The generator shall meet all requirements of BS5000 in design, performance and factory test procedures. The regulator shall be factory wired and tested with the generator.

The generator shall be equipped with a permanent magnet generator (PMG) excitation system. Both the PMG and the rotating brushless exciter shall be mounted outboard of the bearing. The system shall supply a minimum short circuit support current of 300% of the standby rating for 10 seconds. The rotating exciter shall use a three-phase full wave rectifier assembly with hermetically sealed silicon diodes.

The insulation system of both the rotor and stator shall be synthetic and non-hydroscopic. The main rotating field shall be of unit construction. The rotor core shall be shrunk-fit and keyed to the shaft.

The stator winding shall be of 2/3-pitch design to eliminate the third harmonic and shall have class H insulation.

The temperature rise of both the rotor and stator shall be in accordance with the applicable sections of BS5000 part 99 for class H insulation. The generator shall be self-ventilated.

The regulator shall be solid state with no voltage build-up or other type relays acceptable. The voltage regulation shall be + ½% from no-load to full load and 5% frequency variation. Regulator drift shall be less than 1% per 40 0C ambient temperature change.

The voltage regulator shall be a static-type using non-aging silicon controlled rectifiers.

Voltage dip shall not exceed 30% upon application of full continuous rated load at 0.8PF with recovery to steady state band conditions within 4.0 seconds as measured on a light beam recorder. The wave form harmonic distortion shall not exceed 5% total RMS measured line to line at full rated load. The Telephone Influence Factor (TIF) factor shall not exceed 50. Load connections shall be made via a junction box. The generator construction will allow connection to the load through the top, bottom or either side of the junction box.

The conduit box shall contain two compartments; one to house the rotating rectifier and PMG, and the other to house the connection area and regulator. This is to separate the rotating elements from the load connection and voltage regulator adjustments.

The regulator and voltage adjust rheostat shall be mounted on the inside of the junction box and relocation of this assembly to the opposite side shall be possible.

All performance and temperature rise data submitted by the bidder shall be the same result of the actual test of the same or duplicate generators. Temperature rise data shall be the result of full load, 0.8 power factor heat runs at the rated voltage and frequency. All performance testing shall be done in accordance with Institute of Electrical and Electronics Engineers (IEEE) Standard-115.

The generator control panel shall be mounted, by means of vibration isolators. The control panel shall be housed in an enclosure design to withstand the vibration levels of the generator set and shall contain, at the minimum, the following instruments, switches and gauges:

- AC Voltmeter connected through selector switch to read line-to-line voltage, 1-2, 2-3, 3-1. Selector switch shall be labeled to indicate meter connection at each position
- AC Ammeter connected through phase selector switch to three individual current transformers to read phases 1, 2 and 3. Selector switch shall be labeled to indicate meter connection to phases
- Frequency meter, dial type
- kWh meter
- Elapsed time meter
- Manual voltage adjusting rheostat
- Engine Lube Oil pressure gauge
- Water Temperature gauge.

All meters and switches shall be labeled to indicate their function. Labeling shall be neat, easy to read, and permanent. All gauges, meters and switches shall be located for easy visibility and access.

A main line, molded case, 3-pole circuit breaker, to be sized and rated by the contractor, shall be installed as a load circuit interrupting device. It shall be possible to operate the circuit breaker manually, as an isolation switch. The circuit breaker shall operate automatically during overload and short circuit conditions.

The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection.

The circuit breaker shall be mounted in an enclosure, in or adjacent to the generator control panel. An annunciator panel for remote mounting, to give visual and audible indication of impending alarm conditions, shall be provided. An audible alarm (horn or bell) shall be installed to sound continuously when any fault sensor trips. All indicators and alarms shall be reset by manual adjustment on control panel.

The generator set shall have an automatic shutdown system that will include automatic start/stop cranking controls, single crank and cycle cranking with warning lamps to indicate shutdown due to high engine water temperature, low oil pressure, over-speed, over-crank and low jacket water coolant temperature.

The diesel generator set shall start automatically on failure of the AC supply to the station bus. Fault sensors shall be incorporated in the shutdown system to cause emergency engine shutdown when any of the above faults occur.

Fuel shut-off valve shall operate governor to no-fuel position. Shut-off valve shall be operated either manually or automatically.

Power for sensors, trips, indicator lamps and alarm shall be provided by engine cranking batteries.

Individual indicator lights shall be provided in control cabinet for each fault condition. Each indicating lamp shall be labeled according to function.

A diesel fuel storage tank shall be included to provide a 10 day supply of diesel fuel under continuous operation.

1.4.8.12 Solar Electric System

Solar electric system design is beyond the scope of this specification.

1.4.8.13 Lighting, Fittings and Accessories

General
Lighting fittings shall be of fluorescent type with electronic type ballast and have power factor compensation. All fittings shall be delivered complete with lamps.

Indoor Lighting
The lighting fixtures shall be surface mounted. Fittings for indoor lighting shall be IP 23 according to IEC 60529.

Outdoor Lighting
Fittings for outdoor lighting shall be splash-proof IP54 according to IEC 60529. The outdoor lighting shall be operated by means of a photocell relay, connected to a changeover switch, mounted in the lighting board, with three positions: ON; PHOTOCELL RELAY; OFF.

Socket Outlets
Single phase socket outlets shall be Shucko (CEE 7/4), 16A. Three phase socket outlets shall be splash-proof, 3P+N+PE according to IEC 60309. Outlets shall have a load breaker mechanically interlocked with the male device.

Socket outlets shall be provided as indicated in Table 2.4.17.

Table 1.4.17 Socket Outlets

Socket Outlets	
Control room	three 16A, 230VAC one three phase, 16A, 400VAC
Auxiliary room	three 16A, 230VAC one three phase, 16A, 400VAC
Office	three 16A, 230VAC
Store room and workshop	two 16A, 230VAC
Kitchen	two 16A, 230VAC
WC- bathroom	one 16A, 230VAC
Adjacent to outdoor power transformers	one 125A, three phase outlet for oil treatment plant.

Lighting Intensity and Socket Details
The intensity of the lighting installation shall be as detailed in Table 2.4.18.

Table 1.4.18 Lighting Intensity

Lighting Intensity	
Control, battery and auxiliary rooms	300lux
Office and kitchen	300lux
WC/bathroom	200lux
Store room and workshop	200lux
Outdoor, entrance and gate	50lux
Transformer cells	50lux
Switchyard, in general	10lux
Emergency lighting in control room (design for 90 minutes minimum)	50lux

1.4.8.14 Auxiliary DC System

General
The 220V DC systems shall consist of two 220V batteries, two rectifiers, one main battery board and DC distribution board. The 48V DC systems shall consist of one 48V battery, two rectifiers, one main battery board and DC distribution board. Battery supervision shall be included for each. For discharge test of batteries, a portable enclosed resistor and a fused test outlet at the DC board shall be supplied. It shall be possible to adjust the resistor for different load currents.

The DC systems shall be designed for the power demand of the connected loads and a future extension of at least 30%, taking into account the load diversity factor and the maximum voltage drop.

The battery shall have a sufficient capacity for maintaining the power supply of the connected systems for a period of six hours in the event of failure of the AC supply, without the terminal voltage falling below the nominal value by more than 10%. Furthermore, the battery must be dimensioned for a secure and selective operation of the short circuit protection devices (fuses).

The rectifiers shall be designed to recharge the battery, up to 90% of rated C10-capacity within 12 hours after a six-hours discharge, whilst supplying the connected loads at the same time.

The voltage at individual components when the system is at no load must not exceed the nominal voltage by more than 10%, and must not fall below the nominal voltage by more than 15% when the system is at full load.

Batteries
The batteries shall have main design data per Table 2.4.19.

Table 1.4.19 Batteries - Main Design Data

Rated voltage	220 V ± 10%	48 V ± 10%
Normal float charging voltage, maximum	100% x U_N	100% x U_N
Lowest voltage, discharged battery	90% x U_N	90% x U_N
Discharging time (100% of C10)	6h	6h
Recharging time (90% of C10)	12h	12h
Maximum fuse tripping time	5s	5s

The Contractor shall design the capacity of the battery system, using appropriate temperature correction factor, design margin and ageing factor, in accordance with IEE 485 *Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations*. The batteries shall be erected on non-corrosive stands and totally insulated from frames and earthed equipment. The batteries shall be of a type with transparent containers and be installed in maximum two layers in order to enable the observation of the acid level through the container walls. The batteries must be erected in such a way that maintenance and service can easily be carried out. Acid resistant vessels under the batteries shall be included. Each battery cell shall be equipped with explosive retarding valves.

Rectifiers
The rectifiers shall be of solid-state constant voltage charge type and have an automatic current limitation. The rectifiers shall be equipped with volt- and ammeters (accuracy class 1.5), indication lamps, main switch and a selector switch for automatic recuperative recharging (Float/Quick charge with locking device) as well as alarm indicators for AC supply failure, and quick charging. Test outlets for 4mm banana-plugs shall be provided.

Auxiliary contacts for above-mentioned alarms shall be provided for remote alarms, including a no-voltage relay for AC-voltage. The rectifiers shall be enclosed in painted steel chassis with a degree of protection of IP 43 according to IEC 60529.

DC-Supervision
DC-supervision of the battery systems shall be provided and shall, as a minimum, consist of:

- Over- and under-voltage supervision in two steps for each function of the floating voltage level.
- Earth fault supervision.
- Battery circuit supervision.
- Fuse supervision for all fuses.

If the DC-supervision is mounted in the rectifier it shall be connected at the external side of the rectifier fuse to prevent maloperation if the fuse will trip. Auxiliary contacts for the above mentioned alarms shall be provided for remote alarms.

1.4.8.15 Auxiliary Power Cables AC/DC, Wires and Earthing

General
The cables and wires with accessories shall be continuously rated and suitable for service under the actual climatic conditions. The cables shall withstand all electrical, thermal and mechanical stresses under the stated service conditions, and at a voltage of 10% above the rated value. The insulation level shall be 1kV. Special mechanical protection of the cables shall be provided where required. The cables shall be protected against the short circuit current and earth fault current by fuses, with exception of use in current measuring circuits. Cables shall be protected against direct sunshine. Cables shall be marked with designation according to the cable list.

Design
The cables to be used shall be PVC-insulated, PVC-sheathed with copper conductors and copper screen. The neutral conductor shall be of the same cross-section as the phase-conductors. The surface of the sheath shall be marked as follows in English:

- Name of manufacturer
- Year of manufacture
- Cross-section area of phase-conductors and number of cores.

Cable Accessories

General
The minimum requirement for cable joints and cable terminations are that they after installation shall withstand the environmental and climatic conditions as the cable itself. They shall also fulfill the same electrical standards as the cables regarding insulation and current rating.

Cable Joints
Jointing shall be avoided. If jointing is anyway deemed necessary by the Contractor, he shall obtain the approval of the Employer. The jointing of conductor ends shall be done by pressing or screwing technique. The insulation may be restored by taping, molding or shrinking techniques.

Cable Terminations
Connection of low voltage cables to distribution boards, contactor cubicles, motors, etc., shall be carried out by removal of the insulation to the required length of the conductors and by connecting the ends to the terminals. The terminals shall be of screw-joint type. Special cable terminations are thus not needed.

Earth Wires
All switchboards, transformers, apparatus, etc., shall be connected to the main earthing system.

1.4.8.16 Line Protection Signaling Systems

A trip signaling system via an optical ground wire (OPGW) system shall be installed to send/receive all trip signals related to the 220kV and/or 20kV line bays. This shall operate via the Synchronous Digital Hierarchy (SDH) equipment over the interconnecting optical ground wire (OPGW) system. Alternatively, line protection may use independent fibers depending on the Bidder's design.

Receipt of a trip signal from the remote substation shall be visually indicated. In addition, all relay protection, transformer guards, voltage supervision relays, etc. shall however be provided with indication to show that the respective device has been activated. The situation and the reason for any tripping shall be clear to the operator. All indications shall be manually reset.

Teleprotection Equipment
Digital teleprotection signaling circuits shall be provided on the SDH network for all transmission lines. The data circuits shall use the standard 64kbit/s G.703 (ISDN compatible) interface and shall employ multiplex section protection between the communication sites at each end of the transmission line to provide maximum reliability.

Teleprotection signaling equipment shall be provided at the SDH access channel level.

The configuration of the teleprotection systems shall be in accordance with the following:

220kV transmission lines
The Contractor shall provide 2 (two) independent 64kbit/s data circuits and 2 (two) sets of teleprotection signaling equipment for each 220kV transmission line.

The teleprotection signaling equipment shall be supplied, installed, tested and commissioned by the Contractor.

Typically, each 220 kV transmission circuit is protected by two permissive schemes (under reach + over reach) and a direct intertrip scheme in each direction. Therefore at least three protection commands shall be provided for each teleprotection link.

The teleprotection equipment shall ensure, with maximum security, availability and reliability, rapid, full duplex transmission of trip commands (direct or permissive), blocking.

The equipment shall be of modular design and either be mounted into a slot of the communications multiplex equipment or installed in racks within the communications cubicle. It shall employ full solid-state microprocessor controlled circuitry techniques with self-monitoring functions. Exchange of faulty submodules shall be possible without switching off the communications equipment or influencing other channels.

Computerized diagnosis/ testing and easy field programming (alarm levels, selection of permissive tripping/blocking signal features, etc.) of the equipment shall be possible. Programming and diagnosis shall preferably be carried out with a PC to be connected to the teleprotection equipment via a standardized service interface. Additionally, the equipment shall be furnished with local failure indications and potential free contacts for external alarm annunciation. As a minimum, the following alarms shall be generated and announced:

- General (internal) fault
- Auxiliary power supply failure
- Faulty transmission path, exceeding a specified time (e.g. some seconds)
- Signal-to-noise ratio too low, exceeding a specified time
- Continuous command
- Protection signal sent
- Protection signal received.

Test Facilities
A test mode or test points shall allow checking of equipment under operating conditions. It shall be ensured that testing will neither disturb or damage the teleprotection equipment nor cause any malfunction of connected high voltage circuit-breakers. Proper functioning and any malfunctions of the equipment during testing shall be indicated via LEDs. Under no circumstances shall real tripping commands be blocked or limited during tests, in order that full protection of the high voltage system is maintained. Loop tests shall be possible from each terminal station without the need of personnel at the opposite station.

1.4.8.17 Communications

The communication system supply shall conform to relevant technical requirements of the latest current applicable Standards:

ITU-T	International Telecommunications Union - Telecommunications Standardization Sector
ITU-R	International Telecommunications Union – Radio communication Sector
IEC 60794	Optical Fiber Cables
IEEE 1138	Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for Use on Electric Utility Power Lines
BS6651	Protection of Structures against Lightning
IEEE 1222-2003	Standard for All-Dielectric Self-Supporting Fiber Optic Cable
TIA/EIA RS-598A	Color-coding of Fiber Optic Cables

1.4.8.18 SDH Network

General
The primary optical network connecting substations with the National Load Control Center (NLCC) near Tarakhil and shall be based on Synchronous Digital Hierarchy (SDH) equipment using multiplexed channels on STM-1 (155Mbit/s) links for data, telephony and protection signaling. The SDH equipment at each site shall be linked via optical fiber cable on the transmission lines (generally OPGW) or via microwave radio where specified.

The SDH equipment is required eventually to fit in to a system wide communications network so the scope of supply shall include provision of equipment for future fiber optic links. In addition multiplex and sub-network connection protection is also required so some duplication is specified.

Network Services
The SDH network shall provide the following services:

A. Telephone Network

The telephone exchanges (PABX) at each substation shall be linked over the SDH network by 2Mbit/s G.703 E1 circuits.

B. SCADA Data

Digital communications shall be provided to connect the Remote Terminal Unit (RTU) of the CSCS at each site with the Network Control Center (National or Area Load Control Center) at Tarakhil. 10Mbit/s IEEE 802.3 Ethernet data links shall be provided over the SDH. In addition, asynchronous serial links shall be provided for other equipment that may need interconnection.

C. Teleprotection

Digital teleprotection circuits shall be provided on the SDH network for all transmission line protection as described above.

D. Performance

The technical requirements of the equipment specified for the communications network are based on ITU-T Recommendations and other international standards. Error performance objectives shall comply with ITU-T Recommendation G.826.

E. Redundancy
Each SDH terminal shall communicate via two separate fiber circuits in an actual ring or flat ring configuration. Where possible, these circuits shall be connected by separate transmission lines to form a true ring.

1.4.8.19 SDH Multiplex Equipment

General
Digital multiplex equipment shall be provided to perform the necessary multiplexing between 2Mbit/s and 34Mbit/s tributaries at each site. The digital multiplex equipment shall also provide the optical interfaces to the fiber optic cables between the various sites. The digital multiplex equipment shall be in accordance with the latest ITU-T Recommendations for SDH equipment, namely; G.703, G.707, G.708, G.709, G.781, G.782, G.783, G.784, G.803, G.811, G.823, G.825, G.957 and G.958.

Interfaces
The types of interfaces required are:

- STM-1 Optical
- n x 2 Mbit/s
- The characteristics of the multiplex interface shall conform to the ITU-T Recommendations for systems operating at 155 Mbit/s or 52 Mbit/s, namely:
- G.709 for mapping and de-mapping
- G.708, G.783 for MSOH and RSOH insertion and extraction
- G.708 and G.709 for POH generation and termination
- G.709, G.783 for Pointer generation and interpretation
- G.708 for multiplexing
- G.709 for scrambling and de-scrambling.

STM-1 Optical Interface
Optical interfaces shall be provided for connection to the fiber optic cable between the various sites. In addition to the general requirements listed above, the STM-1 Optical Interface shall conform to the requirements listed in ITUT Recommendation G.957.

The interface shall operate at a nominal optical wavelength of 1550nm and be suitable for operation over the required distances. The optical fiber on these routes shall conform to the ITU-T Recommendation G.652. For each link, the optical interface with the lowest transmitter output power that still meets the performance objective shall be supplied.

The STM-1 Optical Interface card shall include flexible patch cords to connect the optical interface to the patch panel. The patch cords shall be terminated at the patch panel end in Type FC/PC connectors. These connectors are also preferred for the STM-1 Optical Interface.

n x 2Mbit/s Interface
2Mbit/s interfaces are required at each site to connect to primary multiplex equipment. Each interface card should accommodate at least 4 x 2Mbit/s interfaces to provide the immediate requirement together with spare capacity for future growth. All 2Mbit/s interfaces shall conform to the ITU-T Recommendations:

- G.703 section 6 for electrical characteristics. The 120 Ω balanced pair option shall be used.
- G.704 for functional characteristics
- G.823 and G.783 for output jitter and jitter tolerance

The 2Mbit/s interfaces termination shall be 120 Ω balanced.

Synchronizing
If a Primary Reference Clock for the synchronization of the SDH equipment is required, it shall be installed at the same location as the network management system and comply with ITU-T Recommendation G.811.

Each multiplexer shall have the ability to choose the timing source between external timing, incoming STM-1 signal (155Mbit/s) or incoming 2Mbit/s. The order of priority in which these sources are chosen shall be programmable by the Employer.

The synchronization architecture shall conform to the recommendations in ITU-T Recommendation G.803 section 6. Where required according to G.803, the Contractor shall provide slave clocks compliant with ITU/T Recommendation G.812. Also, the synchronization using the ring shall be configured in such a way that synchronization is not lost to any loop node with any single break in the ring.

The SOH (Section Overhead) bits Z1 (b5-b8) shall be used to carry synchronization status messages as defined in the ITU-T Recommendation G.708. These status messages shall determine the source of the clock during normal and abnormal operation and shall be used to provide a robust synchronization network as described in ITU-T Recommendation G.803 section 6.2.7.

Each multiplexer shall be provided with a synchronization output interface conforming to ITU-T Recommendation G.703 section 10.

Jitter and Wander
The jitter tolerance on the STM-1 interfaces (155 Mbit/s) shall be in accordance with the ITU-T Recommendations G.825 and G.958. The output jitter shall be in accordance with ITU-T Recommendations G.783, G.825 and G.958. The jitter transfer function shall be in accordance with ITU-T Recommendations G.783 and G.958.

Channel Assignment
The multiplex supplied in the Contract shall be configured by the Contractor to provide the specified reliability for the various types of services.

The Contractor shall submit detailed multiplex design / channel assignment information to the Employer's Representative for approval prior to commencement of manufacture.

Installation
The multiplex equipment supplied in the Contract shall be installed and tested by the Contractor. Following this testing, the equipment shall be subjected to an availability test to prove compliance with the ITU-T Recommendation G.826.

1.4.8.20 Management and Maintenance

Network Management
A Network Management System (NMS) based on Open Systems architecture conforming to the ITU-T Recommendations M.3010 and G.784 shall be provided for the SDH network. This shall be provided as portable system incorporating the NMS software installed on a notebook/laptop PC together with appropriate interfaces and leads to allow the system to be easily moved between the areas covered by this Contract. Local interfaces shall be provided at each site to allow connection of the NMS.

The individual network elements (i.e. DXC and ADM units) supplied to this Specification shall be interconnected as a managed SDH sub-network according to the architecture of Figure 3.4 of ITU-T Recommendation G.784.

In connecting the network elements to form this sub-network, the data channels used shall be configured in a ring-protected arrangement so that no network management capability is lost in the event of failure of any part of the ring.

The interface to each network element shall be a Q3 interface as defined in the ITU-T Recommendation G.773.

Maintenance Functions
The Bidder shall provide details of alarms and parameters monitored in the multiplex equipment and presented to the network management interface. As a minimum, these parameters shall include those listed in section 4 ITU-T Recommendation G.736.

In addition to signaling external alarms, these fault conditions shall generate consequent actions as listed in Table 1 of ITU-T Recommendation G.736.

Control or Service Terminal
Each network element shall be provided with an ‘F’ interface to allow maintenance staff to locally interface to the network element with a hand held terminal or portable computer.

The maintenance technician shall be able to access locally all the information on alarms, settings and statistical information from each network element at the site. He shall also be able to change all software settings. The procedure for updating these software settings shall be designed to minimize the risk of the maintenance technician causing an inadvertent malfunction of the equipment.

The Bidder shall also provide details of measurements and settings that can be controlled on the radio with this terminal.

1.4.8.21 Telephone System

General
A modern digital Private Automatic Branch Exchange (PABX) shall be provided for each substation and switching station. Each PABX shall be inter-connected via 2Mbit/s G.703 E1 digital trunks over the SDH network.

The PABX shall be fitted with a 4-wire + E&M trunk to allow it to be connected to the local PSTN trunk at some time in the future, however for this project the Contractor shall supply and install two optical isolators and connect two incoming PSTN extension circuits, which will be arranged by the Employer. One PSTN extension shall be connected to a tele-facsimile (fax) machine and one to a telephone.

Telephones and Faxes
The requirements for telephones and faxes at each site are:

Digital operator’s console: 1
Analogue telephones: At least 6 (one connected to a PSTN line)
Fax machines: 2 (one on an internal extension and one on a PSTN line)

Telephones shall be installed at suitable locations within each station including in each office (if provided) and at the main operator's desk. A fax machine shall be installed beside the main operator's desk.

The digital operator's console for the PABX shall be located on the main operator's desk.

A structured cabling system shall be provided for the telephone network throughout the station and telephones shall be connected via suitable plug-in wall sockets located in convenient positions.

Administrative software for the PABX shall be provided and installed on the NMS PC. The necessary connection cables shall be provided. The administrative software shall allow easy configuration (adds, moves and changes) by the operator and provide an ability to collect and display error messages, traffic statistics, billing information etc.

PABX Facilities
The PABX shall have the following facilities:

- Subscriber interface
  - 16 x Analogue ports, expandable to 32 ports
  - 1 x Digital port.
- Trunk interface
  - 1 x Trunk 4-wire + E&M port, expandable to 2 ports
  - 1 x Trunk FXS-FXS (hot-line)
  - 1 x Trunk 2Mbps port expandable to 2 ports
- 1 x RS232 local maintenance communication port
- Cable as required
- Power supply: 230V AC station UPS supply, 220V DC battery supply or 48V DC communications supply.

Requirements for the PABX:

Hardware
The PABX shall be of the Stored Program Control type constructed on modular principles. It shall be designed for full availability and be of the non-blocking type. It shall be constructed from components that require no routine maintenance.

The specified line and trunk expansion shall be achieved by no more than plugging in additional cards.

Software
The operating software and PABX configuration shall be stored in non-volatile memory. When new system firmware is available it shall be possible to upgrade the unit locally with the support of the configuration system supplied.

The PABX configuration software shall be supplied and installed on the computer as specified above.

Numbering Principle
The numbering capability of the system shall be flexible with at least four digit numbers being used for internal extensions and four or five digit numbers for dialing other subscribers on the telephone network.

The numbering plan shall be agreed with the Employer before implementation.

Features
The PABX equipment shall provide the following:

- Automatic connection by dialing between all internal subscribers
- Time billing for trunk calls
- Direct dial in
- Local extension to/from remote extension dialing
- QSIG (PSS1) support
- Conference call (up to 8 parties).

The operator console shall be an LCD screen based system and shall provide the following functions:

- Call hold
- Call transfer (internal and external calls)
- Break-in (intrusion)
- Call release
- Hands-free operation
- Delayed ringing
- Ability to connect hotline with telephone extensions
- Display call status information on the LCD screen

For subscribers, the following functions shall be supported:

- Personal access code for dialing outside line (PSTN network), (or otherwise external trunk access shall be provided via the operator)
- Call park/hold (camp on)
- Call forward/divert
- Call waiting
- Recall
- Direction select (call pickup)
- Speed Dialing
- Last number redial
- Hotline

1.4.8.22 Very High Frequency (VHF) Communication Systems

A VHF communication system is required for voice communications. The system allocated frequencies are 163.425MHz and 163.325MHz.

The scope of supply shall include, but not be limited to, the following:

- VHF transceiver with code calling facility
- Power supply unit for base sets
- Antenna tower, Minimum 18m, including guys, line traps, coupling devices, foundations, etc.

The transceivers shall conform to the following specifications:

- RF output power: 30 Watts nominal
- Nº of switchable channels: 6 Frequencies matching with the existing system
- Channel separation: 25kHz

- Frequency control: Synthesized
- Display: Digital LED/LCD
- Audio output: 2 Watts with less than 10% distortion
- Controls: Power, volume, channel selection, code calling, operator selectable channel scan function, etc.

The Contractor shall ascertain the height of the VHF antenna tower at all substations and switching stations after carrying out a VHF survey. The minimum height of the antenna tower, however, shall be 18m as specified above. The RF output power shall be ascertained by the Contractor after carrying out survey and design according to ITU standards.

The VHF mast shall be of galvanized steel. Aviation obstruction lights to be provided on VHF mast shall conform to the requirements of the Employer. The design wind velocity is 185km/hr.

The base antenna shall be an omni-directional ground-plane antenna. Maximum power input shall be 100 Watts with VSWR on tuned frequencies of 1.2.

The base antenna coaxial cable shall be of copper conductor polyethylene foam insulated type. The attenuation shall not exceed 1.5dB per 100 meters at 40MHz. The characteristic impedance shall be 50 ohms.

1.4.8.23 Computerized Substation Control System

General
This covers the design, manufacture, supply, installation, testing, commissioning and handing over of a microcomputer-based substation control system suitable for operation and data recording of the substations. All materials and parts that are not specifically mentioned hereinafter but are necessary for erection, assembly and operation of the equipment shall be furnished and are deemed to be included in the scope for this sub-section.

The Computerized Substation Control System (CSCS) shall be a microcomputer-based control and monitoring system and include protection functions.

A CSCS system is required for all substations.

Design and Operation
The arrangement shall follow the latest engineering practice, ensuring optimum continuity and reliability of supply and ensure the safety of equipment and the operating staff. The highest degree of uniformity and interchangeability shall be provided.

All components shall be suitable for the local climate; storage of equipment shall be possible in closed rooms without air conditioning at a maximum ambient temperature of 55°C. The system offered shall be suitable for operation under electrical conditions (including electrical discharge and disturbance levels) existing in high voltage substations.

The equipment shall be pre-assembled and pre-programmed at the Contractor's works. It is understood that all auxiliary facilities/devices and services necessary are to be provided, i.e. for generation of database of displays programming and testing, adjustments, parameter setting etc.

The design of the system shall be such that personnel without any computer background shall be able to operate the system with ease and shall incorporate user-friendly features without causing undue operational delay.

The design of the hardware and software shall be suitable for 220/20kV voltage levels used by the Employer to enable a standardized layout.

The CSCS shall be designed for easy modification of hardware and software and for easy extension of the substation. Maintenance, modifications or extension of components shall not require a shutdown of the CSCS. Self-monitoring of single components, modules and data transfer channels shall increase the availability and reliability of the equipment and minimize maintenance requirements. Failure of individual components shall not force a total system failure.

The entire substation shall be controlled and supervised at station level, while individual 220kV and 20kV bays shall also be protected, supervised and controlled from the appropriate, control and relay panels. It shall not be possible to control the 220kV and 20kV bays at the same time from the station and individual bay level.

The bay units shall be independent of each other and the operation shall not be affected by any fault occurring at the station level or in other bay units of the substation.

Each substation control system shall consist of the following main parts:

- Man Machine Communications (MMC)
- Substation Control Computer
- Serial high speed bus for data transmission between the different components via fiber optic links
- Bay Units (BU) for local control and protection
- Feeder related local control panels with mimic diagram pushbuttons and selector switches.
- 10Mbps Ethernet interface for remote communication over the SDH network.

The MMC system shall only contain information that is related to presentation and control of the substation.

Substation Control Supervision Functions
All control and monitoring functions have to provide for a secure and reliable operation of the substation, the following are the minimum functional requirements:

- Input of binary and analogue values
- Control, interlocking, protection and supervision of the bays of the substation
- Alarm handling in the bay computers and in the station computer
- Analogue value processing
- Indication of the bay and substation status
- Indication of measured and processed analogue values
- Station control via a monitor system
- Automatic chronological control of standard switching routines
- All hardware, software and telecommunication facilities for future remote control and supervision of the substation from a future Network Control Center.
- Emergency control of each bay from the related control panels
- Synchro-check functions for all breakers
- Display of trend values
- Fault indication
- Event recording
- Evaluation and archiving of historical data.

Man Machine Communication System (MMC)
The MMC system shall be a high performance operator station with one operator workplace. The following functions are required:

- Presentation of user defined displays (switching status and analogue values), standard displays, trend curve displays and reports
- Effective and safe dialogues for manual control of the substation and for release of control sequence. Select before operation procedures are required
- Presentation of alarms and events on the operator's monitor and printouts on the printer.

The HMI workstation shall incorporate security such that an operator has to log on by entering a user name and password before any interaction with the HMI is allowed. The system shall log any user out of if there has been no input activity for a user settable time.

The HMI computer system shall be Personal Computer (PC) based and shall include or be equipped with the following minimum features:

- High speed 64-bit Dual Xeon central processing units with processor clock speed of at least 2.66GHz, or if a RISC based processor is used, at least 1.5GHz
- Minimum of 12GB DDR3.
- Minimum of 1TB Hard Disk Drive.
- 2GB NVIDIA Quadro 4000
- Windows 7 Professional 64-bit
- CD Read/Write, DVD Read Drive.
- One x 10BaseT/100BaseTX Ethernet LAN port.
- 101 key AT-type keyboard or equivalent
- Optical mouse with at least 2 buttons.
- At least one RS232C serial port.
- Parallel port
- At least 3 USB ports.
- High performance graphic card with a minimum resolution to 1280 x 1024 and 16.7 million colors that supports up to two monitors.
- Two LCD flat screen monitors supporting up to 1280 x 1024 pixel resolution and 16.7 million colors. Each monitor shall have a viewable area measuring at least 19 inches on the diagonal.
- Audio support and speakers.

The MMC shall include two high-speed printers with a standard RS232 interface. The first printer shall be a black and white type for continuous listing of all events occurring in the substation. A second color printer shall be supplied for graphic hardcopies of the displays and for reports.

Both of the printers shall be compatible with the portable servicing unit specified below. The printers shall be capable of printing on single sheet A4 and shall be supplied with 40 ink cartridges for each ink jet printer and 40 toner cartridges for each laser printer. In addition, 40 reams of paper per printer shall be supplied.

The operator's keyboard shall have function keys that are configured to allow direct access to specific displays and functions. The operations procedure should be simple and easily understood.

The configuration of new displays shall be possible without taking the CSCS off line.

A DC/AC converter suitable for connection to the station battery shall supply the AC power for the MMC computer, monitor and printers.

Bay Computers

The bay computers shall be based on a microprocessor technology and a real time operating system.

The bay computers shall perform all bay internal programs, command sequences, collection of signals and information, outputs of commands and signal processing including the processing of the signals from the protection system required for the different switchgear units of the corresponding bays.

Generally the following tasks shall be performed:

- Signal acquisition including signals from protection systems
- Acquisition of measured and counted values
- Monitoring of execution of commands
- Data pre-processing
- Data communication to the station computer and connected subsystems
- Calculation of derived operational measured values
- Generation of group signals
- Self-monitoring routines.

Power supply to the computers shall come from the station battery. The bay computers are placed together with all necessary input/output equipment in panels in the relay room of the substation control building.

Emergency control is defined as control without electronic assistance. In this status other control of this bay is without interlocking. The emergency control requires a special key. Normal control of the bay from the station computer shall be disabled, if the emergency select key is in the emergency operation position.

The electronic system shall be provided with functions for self-supervision and test. Each circuit board shall contain circuits for automatic testing of its own function. These circuits shall interact with a test and diagnostic program controlled by the central unit.

Faults in a unit have to be indicated by the illumination of a red LED on the front edge of the unit. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also comprise the power supply system, the internal system bus and the ability of the central unit to communicate with different circuit boards.

The power supply system shall have test terminals for all voltages used in the system.

The function and design of the switchgear interlocking systems shall be extremely reliable and safe. Perfect collection and processing of all switch-gear position of the whole substation must be ensured at all times and unclear information, such as intermediate switchgear positions, switchgear faults, faulty data transfer etc., must never allow switching operations. Control regulation and synchronizing functions shall require perfect collection and processing of all substation information. The information must be up to date and valid. Mal-operation of control and regulation facilities such as on-load switching of an isolator, switching on in an asynchronous state etc. shall be avoided. When the station level control and indication facilities fail, back up control shall be possible.

Station Computers

The CSCS shall include a computer for supervisory functions. This computer shall be equipped with a high performance microprocessor and a real time operating system.

The station computer shall have access to all sub-systems at the bay level, collect signals and information, issue commands and perform the signal processing required for the substation.

The computer shall be placed together with all necessary input/output equipment in panels in the control room. 220V DC from the station batteries shall supply the computer.

LEDs shall indicate the status of the respective circuits on the front of each input/output module of the station computers.

CSCS Communication System
Data shall be transmitted between bay and station computers by high-speed fiber optic data bus.

Presentation, Supervision and Control
The CSCS shall be equipped with two monitors, which are connected to the station computer. Display selection, parameter setting, alarm acknowledgement, selected printouts of reports and command outputs shall be performed from the operator's keyboard.

The system offered has to distinguish between alarm lists and event lists, selectable on the monitor by the operator. As well as the lists on the screen, there shall be a chronological print out of any alarm or event in an event log.

An acoustic alarm shall sound to indicate abnormalities (alarm conditions) and all unacknowledged alarms shall be presented on any screen selected by the operator. The alarm shall be silenced by keyboard or pushbutton action.

As a minimum, the following items shall be presented by the CSCS:

- Station diagram showing the switching status of the substation
- Diagrams of the different voltage levels
- Substation overall alarm lists
- CSCS internal alarm list
- System status list
- Substation overall event log
- Section event list
- Event and alarm log.
- Trend graph showing critical station parameters such as import/export power and bus voltages.

Station Diagrams and Station Control
The operational status of the substation, measured values of currents, voltages, active and reactive power flows, are to be presented on the displays. The station displays shall present diagrams for each substation voltage level.

One display shall be able to show a single line with all the relevant data. The displays shall not take longer than 2 seconds to be updated, after selection by the operator. Layouts of the displays are subject to the approval by the Employer, the Employer's Personnel shall also be trained so that they can reconfigure the single line diagram.

To ensure a high degree of security against unwanted operations, a special operation procedure requiring "select before execution" shall be provided. After "selection" the operator shall be able to recognize the selected device on the screen and all other switching devices shall be blocked.

The computer shall check the interlocking conditions. The operator can only execute the command if the device is not blocked and interlocking conditions are not violated. After command execution the operator shall receive a message, either about the new switching position or that the switching operation has been unsuccessful or has been refused.

An integrated voltage-check and synchro-check function shall also be provided (separate from that used for auto-reclosing) for manual closing of the circuit breakers. The voltage-check function shall include live-bus/dead-line conditions, dead-bus/live line conditions and dead-bus/dead-line conditions. It shall be possible to set or sect any combinations of these conditions that will allow closing. For live-bus/live-line conditions the synchro-check function shall take precedence.

The synchro check function shall allow circuit breaker closing only if the voltages on both sides of the breaker fulfill the pre-set conditions as to magnitude, phase and frequency difference. The voltages shall be considered in synchronism when their phase angles are measured to with the angle adjustable from 20 to 60 degrees. During synchronizing a closing order shall only be accepted, if the synchronizing conditions are fulfilled.

Alarm List
Faults and errors which may occur in the substation have to be tabulated in the substation alarm list and have to be processed in order to allow them to be transmitted in future to the Network Control Center. The alarm list shall replace a conventional alarm table. The alarm list shall constitute an actual evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults.

Date and time of occurrence shall be indicated. The time shall be displayed beside each alarm.

The operator shall be able to select pictures which contain only a section or subsection of the substation overall alarm list. The operator shall be able to acknowledge alarms at the keyboard. Acknowledged alarms shall be marked in the list.

Faults that appear and disappear without being acknowledged shall be specially marked in the alarm list. The alarm list shall be presented on the display screen. It shall be possible obtain hardcopy on the printer.

CSCS Internal Alarm List
The CSCS shall constitute an actual evaluation of internal CSCS alarms, e.g. of defective CSCS input/outputs or defective CSCS communication nodes. It shall contain unacknowledged alarms and persisting faults.

System Status List
The system status list shall show the CSCS configuration and the status of all devices in CSCS system.

Event List
The substation event list shall contain events that are important for the control of the substation, e.g. "Circuit Breaker Closed". The time has to be displayed before each event. The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it. A printout of each display shall be possible on the hardcopy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. The latest 600 events shall be stored in the computer. Previous information shall be obtainable from the printed event log. The chronological event list shall contain:

- Control operations initiated by the operator

- Indication of change of position of circuit breakers, disconnectors and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Changes in the upper/lower limits of analogue measured values.

Event and Alarm Log
The event and alarm log shall consist of the spontaneous listing of events and alarms on the event printer. This log shall contain the same events as mentioned above, but chronologically printed as soon as they occur. Additionally, the event log shall contain all alarms, with the time of each occurrence. Each alarm shall be configurable, so that a second alarm message can be printed if the alarm disappears. Events which occur when the printer is off-line (e.g. because of being out of paper) shall be queued in the computer until the printer is again available.

Quantity of Input and Outputs
The signals to be primarily handled are at the 220kV and 20kV level, as indicated by the station single line diagram. The following signals shall be considered as a minimum:

A. Binary inputs (single indications):
   - 8 per circuit breaker
   - 5 per disconnector
   - 4 per earthing switch
   - 16 per line feeder from protection
   - 6 from busbar protection; (220kV only)
   - 50 general auxiliaries for the whole substation.
B. Binary outputs (single commands):
   - 2 per circuit breaker
   - 2 per disconnector
   - 2 per earthing switch.
C. Analogue inputs (8 bit measurement):
   - 3 voltages per respective busbar sections
   - 3 voltages per line feeder
   - 3 voltages per transformer feeder
   - 3 currents per line feeder or bus-coupler
   - 1 active power per line feeder
   - 1 active energy counter per line feeder
   - 1 reactive power per line feeder
   - 1 reactive energy counter per line feeder
   - 3 currents per transformer winding
   - 1 active power per transformer
   - 1 active energy counter per transformer
   - 1 reactive power per transformer
   - 1 reactive energy counter per transformer.

The measurement transducers shall be integrated in the CSCS at the bay level. In place of transducers, analogue values may be obtained via serial data link from protection relays, intelligent power monitors or other Intelligent Electronic Devices (IEDs).

Power transformer
All the status indications, binary outputs and analogues supplied with the power transformer and on-load tap changer shall be made available to the CSCS and allowed for when sizing the CSCS, including:

- Temperature alarms and trip signals
- Oil temperature alarms and trip signals
- Buchholtz trip
- Group alarms from MCB in the local control cubicle
- Status of the cooling fan groups etc.
- Tap position of the tap changer
- Commands for raising and lowering the tap position etc.
- Local/remote
- Master/Follower

The measurement transducers shall be integrated in the RTU at the bay level, e.g. in the relay panel associated with the bay. The CSCS shall be capable of continuously trending a minimum of 20 data items selectable by the operator.

Servicing, Testing and Programming Equipment
Three portable servicing, testing and programming units shall be supplied. They shall be based on a standard laptop computer and portable printer. The portable servicing units shall be used for application programming, documentation, testing and commissioning. The portable servicing units shall be supplied with a CD ROM burner, 1000 CD ROM blank discs, and three 56 KBPS Modems. Any specialist software required shall be supplied free of charge, the specialist software shall include any future upgrades, user fees, support fees and license fees.

The laptop-based portable servicing units shall be used for the following purpose:

- Program entry
- Program testing
- Fault tracing
- Program amendment
- Graphical program documentation
- Uploading and downloading of programs including CMOS etc.
- Commissioning
- Reading of values in the data base
- Changing peripheral parameters
- Programming/reprogramming of RTUs if software configurable.

The portable servicing units shall permit the user to study changes in the substation. The units shall be able to monitor data in the CSCS while the system is in use and to present changing variables on the display screen, selectable in a tabular or graphical format. The portable servicing units shall be supplied at the beginning of the commissioning period and be available for training of the Employer's personnel.

The programming entry procedure shall be based on a graphical user interface that provides the operator with visual control of the work.

The portable servicing units shall deliver alphanumeric and full graphical documentation of the work such as printouts of the application program in graphical form.

Both of the event printers of the MMC shall be compatible with the portable servicing unit. The event printers shall be capable of printing on single sheet A3 and A4 and shall be supplied with 40 ink cartridges (or toner cartridges) each, and 40 reams of paper per printer.

The engineering ports of all IEDs (protection relays, fault recorders, voltage regulators, RTUs, CSCS etc.) shall be connected via a serial network so they can be remotely interrogated from the

Network Control Center when it is commissioned. A suitable interface with the SDH communications equipment shall be provided for this purpose. For example, one or more Terminal Servers may be provided on the Ethernet LAN.

Software Capabilities
The software shall consist of basic software modules and standardized supplementary function modules, the parameters of which can be changed depending on the layout and operational concept of the substation, as the operation and configuration of the substation may change over time. The software shall be either UNIX or LINUX based; or alternatively, MS windows operating system, with Windows 7 Professional 64 bit or latest Windows Server.

Security of control selections is of paramount importance and every precaution shall be taken in the software and hardware design to ensure that spurious control operations are rejected by the system and cannot occur. Failure of communication either partial, total, intermittent or permanent, shall not lead to an erroneous control actions. Noise, either spuriously occurring or injected manually into any communication link shall not lead to a false control action.

The system software shall be standard software that has been in use by other customers.

The system shall restart automatically after failure or loss of supply voltage, and no real time data collected up to the time of power failure shall be lost. After restart, the system shall automatically boot up into operational mode. It shall be possible to test the CSCS while the substation is live and being controlled by the CSCS. The testing shall not present any hazards to the safe operation of the substation. Test facilities shall include functional and data tests.

The following software programming shall be deemed to be included in the scope of supply of the equipment and services as a minimum:

- Design of the data base including entering all substation data
- Design of one overall display representing the substation
- Design of the displays for each voltage level
- Design of a detailed display for each individual bay
- Design of a display for station auxiliaries.

Station Interlocking and Control Sequence
The control program shall make it easy to reconfigure the system by adding new feeders (lines, transformers etc.) and future modification and extension of the station shall be possible without interference with the operation of other parts of the installation (e.g. moving of existing feeders including all parameters and settings to enable installation of new feeders).

The interlocking concept shall be as follows:

- The disconnector shall be operable only when the relevant circuit breaker is in the off position and the relevant grounding switch has been removed. Busbar change over shall be possible with the busbar isolators and bus coupler in the closed position without power supply interruptions.
- The earthing switch is operable only when the disconnectors have been opened and the circuit is dead (i.e. no voltage)
- Closing of circuit breakers shall only be possible when the relevant grounding switches have been removed and the protective relays and corresponding lock-out relays are not actuated or if they are actuated, the faults have been cleared and the respective lockout relays have been reset.

- When a pressure drop signal is received from gas monitoring devices for SF6 circuit breakers, the tripping and closing signal shall be locked out.
- The interlocking system is to be designed in such a way that testing is possible during normal operation of the CSCS.

Station Metering
The CSCS shall be connected to the digital outputs of the station metering equipment. The station computer software shall include the same software used in the laptop PC supplied for metering analysis. In future the automatic transmission of metering data to the Network Control Center as well as remote setting of meter parameters shall be possible.

Program for the Delivery of Hardware and Software
Before starting the manufacture of the CSCS equipment complying with this specification, the following shall be supplied as early as possible to the Employer:

- A functional design specification (FDS) which describes in detail the equipment and the functions of the system to be installed
- A program for FAT (Factory Acceptance Testing)

Both these documents shall be supplied for approval by the Engineer. Their purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes testing to the degree required before the equipment leaves the factory.

In addition to the above further documents shall be submitted to the Engineer for approval of e.g. the layout of all the station displays, the data base list and the documentation of the software in the form of graphical diagrams. No factory acceptance tests shall be allowed without the approval of the FDS and the FAT.

Documentation
The hardware and software documentation shall comprise of, but not be limited to hard copies and soft copies of the following:

- Front view and side view of all different cubicles (front and side elevations)
- Circuit diagrams for cubicles
- Apparatus lists for cubicles
- Connection tables for cubicles
- Data base listings
- Manuals for the MMC
- Manuals for the station and bay computers
- Programming manuals

All system hardware and software documentation and all the application hardware and software documentation shall be supplied in the English language.

Time Synchronization
Accurate time synchronization shall be provided for all IED internal clocks including the CSCS, the HMI workstation, the Bay level controllers, fault recorder, protection relays and any metering clocks.

The real-time clock or clocks within each device shall be synchronized to within 1mSec of Afghani time (UTC + 04:30:00.000) by a GPS clock provided at each substation and switching station. The GPS clock shall be connected to a suitable GPS antenna installed on the roof of the control building or at another suitable location providing adequate visibility to GPS satellites.

The GPS clocks shall also provide both unmodulated and amplitude modulated IRIG-B signal outputs which can be used for time synchronization. If necessary, a Network Time Protocol server (NTP server) is to be provided to synchronize devices on the substation LAN.

Proof of Quality
Only experienced and technically capable manufacturers of Control and Protection Systems will be accepted. In order to establish their capabilities, the Bidder is required to present the following documents with their bid:

- Block and functional diagrams showing the proposed control scheme
- Technical specifications and descriptions of systems, catalogues of equipment and devices to be used
- Brochures and references of the manufacturer supplying the CSCS
- A list of references of similar CSCS systems installed in the last 5 years.

1.4.8.24 Remote Control

Philosophy
New substations and power stations shall be supplied with a built in SCADA interface, Synchronous Digital Hierarchy (SDH) communications equipment, and telephone equipment. The SDH equipment shall be connected to outgoing fiber optic cable and commissioned to communicate with other substations being supplied under the same contract. The stations shall be configured so they integrate with the overall NLCC SCADA and communications systems.

Interface to the Future Network Control Center
An interface shall be provided to connect to the future Network Control Center (National Load Control Center). This shall be achieved by either providing a physical RTU or by providing a virtual RTU within the Computerized Substation Control System (CSCS). Connection to the Network Control Center will be by 10Mbps Ethernet over the SDH communications system or via serial data communication over Power Line Carrier if provided.

It shall be possible to fully remotely control and monitor each substation from the future Network Control Center. All control and supervision signals available to the local CSCS HMI workstation shall potentially be available to the remote control center interface, and selection of the required signals shall be by no more than configuration of a mapping table or equivalent within the CSCS.

The CSCS shall support both, and be equipped with at least one of the following data communications protocols for the remote interface:

- IEC 60870-5-101/104
- DNP 3.0 (Level 3 implementation)

Note that the NLCC will be responsible for the 220kV HV systems, going down to the 20kV MV circuit breaker/disconnector of the HV/MV transformer.

Minimum SCADA Interface Signals
The following remote interface signals shall be provided as a minimum:

A. Digital inputs:
    - 8 per circuit breaker (status - 2 bits, remote control available, alarms) – HV CBs and MV incomer CB only
    - 3 per disconnector (status - 2 bits, remote control available) – HV DISs and MV incomer DIS only
    - 2 per earth switch (status - 2 bits)

- 16 per line feeder from line protection
- 5 per transformer from transformer protection
- 6 from busbar protection (220kV only);
- 20 communication system status and alarms
- 50 general auxiliaries for the whole substation (typically auxiliary AC and DC system status and alarms, fire alarm, intruder alarm etc.)

B. Digital outputs (commands):
- Open/close per circuit breaker – HV CBs and MV incomer CB
- Open/close per disconnector – HV CBs and MV incomer CB

C. Analogue inputs:
- 3 voltages per respective busbar sections
- 3 voltages per line feeder
- 3 voltages per transformer feeder
- 3 currents per line feeder or bus-coupler
- 1 frequency per busbar section
- 1 active power per line feeder
- 1 active energy counter per line feeder
- 1 reactive power per line feeder
- 1 reactive energy counter per line feeder
- 3 currents per transformer winding
- 1 active power per transformer
- 1 active energy counter per transformer
- 1 reactive power per transformer
- 1 reactive energy counter per transformer.

All the status indications, binary outputs and analogues supplied with the power transformer and on-load tap changer shall be made available to SCADA including:

- Winding temperature and temperature alarms and trip signals
- Oil temperature and temperature alarms and trip signals
- Buchholtz trip
- Group alarms from MCB in the local control cubicle
- Status of the cooling fan groups etc.
- Tap position of the tap changer
- Commands for raising and lowering the tap position etc.
- Local/remote status
- Master/Follower status

1.4.9 Civil Works

1.4.9.1 Execution of Works

The civil works shall include all necessary supply of equipment and materials, design, construction, excavating, refilling, etc. to complete a functioning substation. The civil works shall include the following main parts:

- Forming of the site to ensure correct surface drainage
- Leveling and compacting of substation area
- Gravelling of the complete substation area
- Install control building, office, workshop, storage room, battery room, kitchen and toilet
- Install air conditioning and heating equipment for the control building
- Install water well and storage facility; wastewater and septic tank facility

- Install drainage system for the complete substation area
- Excavation and backfilling as required
- Construct new internal roads
- Construct fences and gates
- Construct new oil interceptor tanks for all transformers
- Construct concrete foundation for all apparatus
- Construct steel structures and apparatus supports as required
- Construct concrete fire protection walls each side of all main transformers.

Leveling of Site
A removal of top soil shall be carried out down to a minimum depth of 0.5m.

The Contractor shall level the area by excavating the high areas and filling and compacting the low areas. Any soft soil or other material unsatisfactory for the leveling work shall be excavated and removed from the Site.

After the bulk excavation and the filling and compacting works have been carried out, the Contractor shall remove any remaining high spots and fill in any depressions so that before the commencement of any construction work, the whole of the area has been leveled to the requisite ground level to the satisfaction of the Employer.

All necessary retaining walls shall be included in the contract.

Setting Out
Before any excavation of filling work begins, the Contractor shall set out accurately all excavation and filling lines according to the drawings and shall satisfy himself as to the correctness of all site levels shown on the drawings. During the work, the Contractor shall ensure that the excavation and filling follow the said lines, and the Contractor shall set out as necessarily as the works proceed, profiles and other markers for leveling purposes and he shall be in agreement with the Employer about the levels of the said profiles and markers.

Excavation
The Contractor shall excavate the ground to the lengths and widths and exact depths as indicated on the drawings required for the construction of the works. In cases where the bearing capacity of the subsoil under foundations or roads is insufficient, the excavation shall be continued to such greater depth as may be necessary. Based on the existing ground water level, the foundations shall not be deeper than necessary. All excavation may be carried out mechanically, but the final shaping and trimming of the sub-grade below foundations, etc. shall be done by hand. The Contractor shall handle and remove as necessary all water from a whatsoever source which may come into the excavations and he shall provide, maintain and remove on completion all planking, strutting, shoring or piling required to support the sides of the excavation.

The Contractor shall report all cases of unsuitable or weak ground to the Employer and shall follow the instructions given by the Project Manger during the excavation works. If due to negligence or mistakes on the part of the Contractor any excavations be taken to a level lower than that shown on the drawings or stated in the specification or required for the works, the Contractor shall at his own cost fill in the voids so formed to the proper level with approved fill material well compacted or, if necessary, under foundations and the like with approved blinding concrete.

Filling and Compacting
Filling of areas and around foundations and backfilling of trenches shall be executed in such a way and to such extra depths as will ensure that final surface after settlement and compacting

conforms to the specified levels. All filling material shall be free from cinders, ashes, refuse vegetation or organic material, boulders and other unsuitable material.

All fill material shall be well compacted by mechanical means until a high degree of compacting is obtained. The filling material shall be placed in even layers of a depth not greater than 0.4m and each layer shall be thoroughly compacted. A suitable power-driven roller of at least 5 tons weight, making at least 10 passes for each layer shall be used. For backfilling of narrow and steep sections, the thickness of each layer shall be maximum 150mm, each layer being compacted to required density by using a vibrating plate compactor. Filling and compacting around any pipes, cables or ducts shall be done by hand using selected materials for a depth of at least 0.5m above such pipes, cables or ducts.

The Employer's instructions regarding the addition of water to improve compacting of fill must be adhered to. For fill under roads and foundations every effort shall be made to compact the fill material at its optimum moisture content for compacting. In any case, the dry density of the compacted soil shall not be less than 95% of the maximum density according to ASSHTO T180.

The complete substation area shall be surfaced with a 100mm layer of crushed aggregate, size 32mm-64mm.

Leveling
Depending on the ground socket level, leveling to the surroundings might be needed. The slope of such shall be between 1:100 and 1:50.

Disposal of Surplus
The Contractor shall remove from the Site all surplus soil or other excavated material not required or not suitable as fill material. Such material shall be transported to spoil dumps located as agreed upon with the Employer.

1.4.9.2 Drainage

The Contractor shall install an adequate drainage system for the new substation area. Building down pipes shall be connected to the drainage system. Open ditches are not allowed within the substation area.

The drainage system shall be designed for the relevant local climatic conditions.

1.4.9.3 Roads

The Contractor shall arrange for roads in the new switchyard for transport of the transformer to the transformer cell and for passage of a car to the control building. The roads shall be about 6 m wide and shall be surfaced with asphalt or concrete.

Irrespective of the type of bituminous surfacing proposed, a prime coat of at least 0.8 litre/m^2 shall be uniformly sprayed to penetrate and seal the surface of the base course.

Concerning the wearing course, the Contractor may propose a double seal coat or premixed asphaltic concrete. The proposal shall account for rates and types of bitumen and aggregates, plant and method of application.

The allowable tolerances are as specified in Table 2.4.20.

Table 1.4.20 Substation Road Tolerances

Substation Road Tolerances	
Thickness	+6mm - 0mm
Level	±20mm
Maximum deviation	-6mm from a 4m straight edge.

1.4.9.4 Foundations

The foundation for the transformers shall be constructed in reinforced concrete, with space for the whole oil volume of the transformer under the crushed aggregate and steel grating.
Transformers shall be separated by a fireproof wall.

Foundations shall normally be placed on virgin soil or well-compacted fill.

If excavation has been performed to greater depth than required, sand or gravel shall be placed at bottom of the pit to bring the excavation to the required elevation. Such material shall be placed and compacted in layers not exceeding 100mm. Excavation pits shall be kept dry during construction and erection of foundations. Backfilling of the pits shall not be carried out until the Employer has inspected and approved the foundation.

Excavated soil may be used as backfill if it is suitable for compacting. Rock and soil not suitable for compacting shall be removed and replaced with a suitable backfill to the satisfaction of the Employer. Backfill shall be placed in layers approximately 150mm thick. Each layer shall be carefully compacted by means of a suitable plant.

1.4.9.5 Building

General
The rooms shall have painted concrete floor, with a sufficient extent of cable channels for installation of control and auxiliary power cables. All cable penetrations in floor and walls shall be sealed with fire resistance material. All cable penetrations in outer walls shall be protected against the ingress of water.

Design
The substation building shall be constructed of reinforced concrete for beams and pillars with brick walls. The construction shall have good thermal isolation to minimize the need of air cooling. Internal walls shall have a fire resistance for 60 minutes. The penetration seals between these rooms shall also meet this requirement. All air inlets and outlets shall be provided with applicable filters to avoid pollution of the rooms. The outer doors and windows shall be sealed.

The design shall provide enough space for erection, operation, service and maintenance of the substation as well as for the future expansion of the control equipment with 100%.

The floors shall be steel toweled and painted in an approved manner with resistant epoxy paint. The internal wall and roof surfaces shall be painted in an approved manner with suitable plastic paint. The external walls shall be painted in an approved manner with suitable plastic paint. Walls below ground surfaces shall be painted with bituminous coat. The quality and colors as well as the application of the paints shall be approved by the Employer. The Contractor shall submit detailed information, samples and the manufacturer's recommendations for the paints for approval. The painting shall be carried out in an efficient and professional manner to the satisfaction of the Project Manager.

Down pipes shall be provided to lead the rain water from the roof to drainage, which shall be adequate to prevent water from entering the building and from the formation of pools on the ground near the building.

Lockable doors, complete with frames, shall be provided. They shall have the same fire resistance as the walls. The doors shall be dimensioned for transport of goods even after the completion of works.

Installations
In order to maintain a temperature in the building below +25°C, air conditioning of wall unit type shall be installed in the control room. The air-conditioning units shall be divided into several units to provide redundancy.

The floor in the battery room shall be provided with a gully made of stainless steel, connected to the sewage pipe.

The floor surface shall have adequate sloping towards the gully and to be covered by tiles. The battery room shall be provided with one exhaust fan with jalousie (louvers) and air inlet with grill and filter.

1.4.9.6 Fire Protection Walls

Fire protection walls are protection against heat radiation, which means they prevent the NARPad of fire and damage of plant and equipment in the neighborhood. The fire protection walls shall be designed according DIN VDE 0101 or equivalent.

1.4.9.7 Fences and Gates

Fences
The Contractor shall design, furnish and install a masonry fence and gates around the whole substation area.

Masonry walls, 600mm thick, shall be constructed around the perimeter of the site.

Any roads inside the compound shall be at a standoff distance of no less than 3.0m from the inside face of the perimeter wall.

The walls shall be reinforced with rebar.

The walls shall be concrete reinforced with native stone masonry veneer.

The height of the walls shall measure at least 2.2m from the inside grade. Inside grade shall in all cases be higher than outside grade.

The wall shall be capped with a cast-in-place concrete capping.

Outriggers shall be installed to support barbed wires and 2 strands of concertina style razor wire.

The ground grade shall slope away from the wall for at least 5m and shall be kept a minimum of 2.2m below the top of wall for a minimum distance of 10m.

The wall shall be designed to prevent visual access to the inside of compound by all pedestrian and vehicular traffic outside the compound which may require the wall to be built at a higher level in some locations.

Any penetrations through the Perimeter Security Wall shall only be for site drainage purposes and shall have force protection such as a welded bar grill, welded grating, or other pre-engineered barrier.

Details of any penetrations shall be produced by the Contractor and provided in the design drawings.

Entry Control Point Gates – Swing Gates
Swing gates shall be designed and constructed as follows:

- Gates shall be K4 swing type.
- Gate shall be a minimum 2.2m tall, with 0.5m of high tension razor wire mounted on top.
- Gate shall be constructed of steel tubing, faced with steel plate.
- The design and construction of the gates shall insure that it is dimensionally stable, square, true and planar.
- Gate shall not rack or deflect when open, closed, or in motion.
- The Contractor shall provide a locking mechanism that holds the gate closed.
- The swing gate will also have a built- in personnel gate with its own locking mechanism.

Optional Chain Link Fencing
At the option of the Employer, chain link fencing and gates may be substituted for masonry walls and steel sliding gates as follow:

The Contractor shall design, furnish and install a chain link fence and gates around the whole substation area including three numbers of 4-point galvanized barbed wire at the top. A bottom tension wire shall be provided. All parts of the fence shall be corrosion resistant, galvanized or aluminum.

The chain link shall have a mesh width of maximum 50mm^2 and each wire shall have a minimum failure load of 2,000N. Straight line posts shall have a minimum bending failure load, applied horizontally on the top, in the most unfavorable direction, of 600N. Top and bottom tension wires shall have a minimum failure load of 5,000N. In case of 2.5m or higher chain link, the top wire shall be substituted by a top rail. Barbed wires shall have a minimum failure load of 3,000N.

There shall be one main gate with one smaller gate for personnel passage. The main gate shall allow for passage of a truck, both gates shall have provision for securing by padlock. Fence posts and gates shall be set in concrete foundations of adequate strength.

Straight line posts shall have a spacing not exceeding 3m. Guyed tension posts shall be inserted each 50m along straight lines. End and corner posts shall be adequately braced. Straight line posts shall have 800mm – 1,000mm deep foundations, either a 6 inch concrete tube filled with concrete, or a directly cast foundation, at least 200mm wide. Foundations for corner or end posts shall extend minimum 1,000mm below surface and consist of either a filled 9 inch concrete pipe, or be a directly cast foundation, at least 300mm wide. The main gate shall be designed with a reinforced concrete foundation connecting both posts.

To prevent small animals from entering the substation, the space between the bottom of the chain link and the ground surface shall be filled in by a concrete curb, either consisting of prefabricated slabs or cast at site.

To prevent dangerous touch voltages, a 35mm^2 copper wire shall be buried 1 m outside the fence and 0.5 m deep. Connections between the fence and the encircling earth wire shall be made each 15m. All corner and gateposts shall be separately connected. The encircling earth wire shall be connected to the station grounding grid.

In case of an insulated (plastic coated) fence, the encircling earth wire may be omitted. Only gateposts will be connected to the station grounding grid. The top and bottom wires (or top rails) will be divided in 50m sections fully insulated from each other.

1.4.9.8 220kV Switchyard

The Contractor shall design and mount steel gantries with supported rigid tubular busbars of a suitable design for the 220kV switchyard. The gantries shall be suitable for the incoming 220kV transmission line(s) and transformer bay(s).

Each 220kV gantry bay shall withstand a load of one three-phase 220kV overhead line of equivalent 2 x 300mm^2. Aluminum ACSR wire, with a slack span of up to 150m. Each 20kV terminal pole shall withstand a minimum load of one three-phase 20kV overhead line of 158mm^2 ACSR conductor, with a slack span of up to 80m.

The 220kV rigid tubular busbars shall be supplied with steel supports, conductor, insulators and accessories. The scope also includes bolted termination clamps and termination arrangements for all outgoing 220kV circuits.

The gantries and busbars shall be designed to ensure adequate clearance to other equipment, transmission lines, distribution lines, vehicles and personnel inside and outside the substation area. The poles used outside the substation area will support the 20kV distribution lines at 9.5m above ground level.

1.4.9.9 Lightning Protection

The 220kV and 20kV switchyards shall be protected against lightning by providing earth wires or lightning rods on the strain portals for the busbars and the overhead lines. The lightning protection wires (earthwire wire) of the incoming lines shall terminate at strain portals (gantries) of the switchyard. The protected zone shall include all switchgear and transformers.

The earthing facilities necessary for lightning protection shall conform to DIN VDE 0141 or equivalent, with particular attention paid to the requirements for lightning protection in outdoor switching stations (e.g. back flashover). Lightning conductor wires and lightning rods shall be corrosion resistant.

1.4.9.10 Control Building

The control building shall include one room for the relay panel and the AC/DC equipment, a battery room, a storeroom and workshop, an office, a kitchen and a WC/Bathroom. There shall be spare space to extend the control relay panels by up to 100%. The entrance into the store and the battery room could also be from outside.

A desk, a chair and a bookshelf shall be placed in the control room as well as in the office room.

1.4.10 Testing

1.4.10.1 Workshop Testing

The type and routine tests described in the IEC recommendations shall be applied, but type tests may not be required if the Contractor can produce evidence of such tests having already been satisfactorily completed on similar equipment.

1.4.10.2 Tests on Completions

The procedures for the Tests on Completion shall be based on applicable standards and codes of practice and recommendations from manufacturers, and shall be specified by the Contractor in a separate document. The procedures are subject to the Employer's review. The extent of the Tests on Completion is tentatively summarized below.

A general check of the entire switchgear and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, labeling, painted surfaces, cables, wiring, pipe work, valves, blanking plates and all other auxiliary and ancillary items.

Checks shall be made for oil and gas leaks and that insulators are clean and free from external damage. A check shall be made that loose items that are to be handed over to the Employer, e.g. blanking plates, tools, spares, are in order and are correctly stored or handed over. Shutters, earthing procedures and the interchangeability of components shall be checked. All interlocking arrangements both electrical and mechanical shall be fully checked and tested.

1.4.10.3 Power Transformers

After completed erection, the transformer shall be inspected and tested as follows:

- Visual inspection for oil leakage and correct erection.
- Insulation test of high and low voltage windings, cables and accessories.
- Functional check of all accessories, including transformers guards, level and temperature indicators, tap changer and heating elements.
- Oil test.
- Visual inspection of oil level, dehydrating breather, valves, control cabinet, electric clearances between live parts and earth, earthing connections.

1.4.10.4 Switchgear and Controlgear

Circuit Breakers:

- Circuit breakers shall be visually inspected.
- Contact resistance tests shall be carried out.
- Operational tests will include local and remote trip/close.
- For SF6 circuit breakers, testing is required on the gas system to prove the gas quantity, its dryness and its dielectric strength. The gas leakage shall also be measured.

Disconnectors, Earthing Switches and Auto-Reclosers:

- Auto-reclosers, disconnectors and earthing switches shall be subject to operation tests to confirm contact pressures, contact resistance, simultaneous operation of all phases and the ease of operation.
- Checks shall be made of the local and remote indications and operation of auxiliary contacts.
- Checks shall be made of the interlock system, both electrical and mechanical, between the disconnectors and earthing switches.

Voltage and Current Transformers:

- Insulation tests at 1,000 volts to earth and between windings.

- All voltage transformers shall be checked for polarity phasing and for secondary output.
- Burden, ratio and polarity check of all current transformers shall be carried out.

Surge Arresters and Surge Counters:

- Surge arresters and surge counters shall be inspected including installation and earth connection tests.

Conductors and Connections:

- Flexible connections shall be tested to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, they shall be checked both before and after use.
- Conductivity tests are required without any exception on all connections and joints that are made on site.
- The required torque shall be checked with a torque wrench for all bolts and nuts.

Earthing System:

- Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints and at the connections to equipment and structures. Checks shall also be made and precautions taken to avoid corrosion on the earthing system.
- The resistance of the earthing system to earth shall be tested and recorded including the method and equipment used to carry out the tests.

Test of Wiring:

- Insulation resistance tests at 1,000V AC for one minute shall if possible be carried out on all AC and DC protection, control, alarm and indication circuits to ensure that wiring is in satisfactory condition. Visual inspection shall be made on cable glands, cable jointing, fuse or circuit breaker ratings and small panel items such as indicating lamps.
- Static equipment which may be damaged by the application of test voltages shall have the appropriate terminals short-circuited.
- Inter-relay, inter-unit and cubicle wiring carried out at site is to be checked to the appropriate circuit and/or wiring diagram. This may be done by using bells or buzzers. DC supplied from the station battery may also be used. Where it is found necessary during pre-commissioning work to effect site modifications to the secondary wiring, site copies of the appropriate schematic and wiring diagrams shall be suitably marked as agreed with the Employer before the circuit is commissioned.
- Loop resistance measurements are to be made on all current transformer circuits. Separate values are required for a current transformer and lead resistances and all measurements are to be recorded on lead resistance diagrams.

Test of Relays:

- All relays are to be examined to ensure that they are in proper working condition and correctly adjusted, correctly labeled and that the relay case, cover, glass and gaskets are in good order and fit properly.
- Secondary injection shall be carried out on all AC relays, using voltage and a current of sinusoidal wave form and rated power frequency. For circulating current protection employing high impedance voltage operated relays, the points of injection for relay

voltage setting tests shall be across the relay and stabilizing resistance. The operation setting for the type of protection is to be established by secondary injection where it is impractical to ascertain this value by primary injection. Injection is to be made across the appropriate relay bus wires with all associated relays, setting resistors, and intermediate current transformers connected.

- Fault setting test to establish the value of current and voltage necessary to produce operation of the relays. These tests are to be carried out by secondary injection applied at the current transformer terminals.

Test of DC Circuits:

- Tests are to be carried out to prove the correctness of all DC polarities, the operating level of DC relays and the correct function of DC relay schemes, selection and control switching, indications and alarm.

Test of Instruments:

- Instruments and instrument transformer circuits shall be checked for polarity of direction and for calibration including any interposing transformers or transducers. These checks shall be made on all current transformer ratios where applicable.

1.4.10.5 On-Load Tests

On-load tests are required but due to the hazards inherent, they shall be carried out under the direct supervision of the Employer. The following tests are required:

- An operation and stability test shall be carried out for on-load commissioning.
- Tests for restraint shall be carried out to prove the characteristics of protective systems with directional characteristics.
- On-load checks shall be made after the protective gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed, as well as to confirm the integrity of the current transformer circuits. Where necessary, voltage readings shall be taken at the terminals on each relay to ensure that loop connections between the relays are complete. Special attention shall be paid to broken delta voltages and residual current circuits where zero voltage or current respectively may not be a proof of the completeness of the circuit.

1.4.10.6 Communication System Tests

All routine tests as specified in the applicable standards shall be carried out on the communication system equipment. Certificates of routine tests carried out on the equipment supplied shall be submitted for approval.

In addition, the following tests shall be carried out:

A. VHF transceiver:
   - RF level
   - Frequency accuracy
   - Loss for speech frequency level
   - Signal levels
   - Nominal impedance and return loss-VF side
   - Automatic gain control
   - Transmit/ receive frequency difference

- Linearity
- Noise generated
- Sensitivity (SINAD value).

1.4.11 Performance

All works shall be executed according to the requirements and in the manner set out in the Contract Documents. The Contractor shall design, construct and supply all materials for manufacture, tests at the manufacturer's works, transport from the works and delivery to the site, erection, tests, carry out all completion works, put into operation, remedy defects during the defects liability period for the above Plant as described in the Specifications and as shown on the Drawings. All components and accessories required for the satisfactory operation of the Plant shall be supplied as necessary.

1.4.12 Training

During the manufacture of the 220kV CB and the 220/20kV transformers, the Contractor shall arrange for factory visits for Employer's appointed personnel. During each visit of 7 days, training shall be given to five Employer's appointed personnel on factory inspections and witnessing of performance tests. During the erection and test period, the Contractor's supervisor shall give 7 days training, information and thorough instructions to the Employer's staff concerning the handling of the plant and the use of the operation and maintenance manuals. The Employer's appointed personnel shall also have the opportunity of taking part in the testing and commissioning of the Plant.

The training shall be performed according to a program approved by the Employer in advance.

1.5 Schedule of Supply

Table 2.5.1 Schedule of Supply

	Item No.	Description	Unit	Qty
Contract 1A (Lot No. 1): Design, Construct, Test and Commission Salang 220kV Transmission Line (T/L)				
LOT No. 1	**Schedule No. 1.a.1: Transmission Line Design, Drawings and Documentation**			
	1	Structural Design And General Arrangement Drawings	Ls	1
	2	Construction Drawings	Ls	1
	3	As Built Drawings	Ls	1
	4	Maintenance Manual And Completion Report	Ls	1
	Schedule No. 1.a.2: Plant & Mandatory Spare Parts			
	1	Supply Of Towers Including Stub, Bolts, Nuts And Washers, Hangers, U-Bolts Complete Set	Ls	1
	2	Supply Of Complete Tower Accessories	Ls	1
	3	Supply Of Complete Tower Grounding / Earthing Materials	Ls	1
	4	Supply Of Line Materials For Conductor And OPGW	Ls	1
	5	Spare Parts And Tools	Ls	1
	Schedule No. 1.a.3: Construction, Installation, Testing & Commissioning			
	1	Preliminary Works	Ls	1
	2	Foundation Construction Work Associated With Stub Setting And Necessary Survey	Ls	1
	3	Erection Of Complete Towers With Its Basic Tower, Body Extensions, Leg Extensions Including Bolts & Nuts, Tack Welding, Fixing Of Complete Tower Accessories (All Types Of Signal Plates) And Supply And Application Of Enamel & Zinc Rich Paint And Transportation	Ls	1
	4	Installation Of Tower Accessories	Ls	1
	5	Installation Of Tower Grounding / Earthing Material	Ls	1
	6	Installation Of Line Materials For Conductor And OPGW	Ls	1
	7	Protection Of Tower Foundations	Ls	1
	Schedule No. 1.a.4: On the Job Training			
	1	On the job training	Ls	1
	Schedule No. 1.a.4: Total Price for Contract 1A, 220kV T/L (Lot No. 1)			

	Item No.	Description	Unit	Qty
Contract 1B (LOT No. 2): Design, Construct, Test and Commission Substation at Salang Tunnel.				
	Schedule No. 1.b.1: Plant and Equipment			
LOT No. 2	1	220kV Feeder Bays	Ls	1
	2	220kV Transformer Bay	Ls	1
	3	220kV Bus Coupler & Metering Bay	Ls	1
	4	20kV Metal Clad Switchgear	Ls	1
	5	20kV Auxiliary Transformer complete with:	Ls	1
	Schedule No. 1.b.2: Mandatory Spare Parts for Substation			
	1	Protection System	Ls	1
	2	220kV Control Equipment	Ls	1
	3	LV AC System	Ls	1
	4	DC Distribution System	Ls	1
	5	HV Equipment	Ls	1
	6	20kV Metal Clad Switchgear	Ls	1
	7	Power Transformers	Ls	1
	Schedule No. 1.b.3: Standard Tools for Substation			
	1	Substation Maintenance Tools & Appliances	Ls	1
	2	20kV MV Cables	Ls	1
	3	20kV Metal Clad Switchgear	Ls	1
	Schedule No. 1.b.4: Substation Plant & Equipment Supplied from within the Employer's country. Including mandatory service and maintenance parts, standard tools & consumables			
	1	Substation	Ls	1
	Schedule No. 1.b.5: Design, Drawings and Documentation (Substation)			
	1	Substation	Ls	1
	Schedule No. 1.b.6: Substation Installation and Other Charges (Substation)			
	1	Project Management	Ls	1
	2	Project Reporting	Ls	1
	3	Project Insurance	Ls	1
	4	Transportation cost other than included in Schedule 2	Ls	1
	5	Compliance with MOSS	Ls	1
	6	Installation and commissioning of Moqor Substation as follows:	Ls	1
	7	On-Site training during construction and commissioning for six (6) persons	Ls	1
	8	Other Items not already covered	Ls	1
	Schedule No. 1.b.7: Transfer of Knowledge (Substation)			
	1	Training of Operation & Maintenance Staff	Ls	1
	2	Operation and Maintenance training program complete	Ls	1
	Schedule No. 1.b.8: Total Price for Contract 1B, Salang Substation (Lot No.2)			
	Schedule No. 1.b.9: Salang SS Recommended Spare Parts			

	Item No.	Description	Unit	Qty
Contract 1C (LOT No. 3): Design, Construct, Test and Commission Medium Voltage Sub-Transmission Feeder at Salang Tunnel.				
Lot No. 3	**Schedule No. 1.c.1: Total Price for Contract 1C, 20kV Feeder (Lot. No. 3)**			
	1	20kV Sub-Transmission Feeder - OH	Ls	1
	2	20kV Sub-Transmission Feeder in Raceway	Ls	1
	3	20kV Sub-Transmission Feeder - UG	Ls	1
	4	20kV Revenue Metering Equipment	Ls	1

Schedule No. 1.d: Grand Total (Lot. No. 1, 2 and 3)

2.0 Technical Data Sheets

Specified clearances shall be considered minimums. The supplied values are elevation dependent and have been provided for information only. The designer shall consider elevation and adjust clearances tendered and applied to equipment design.

2.1 Transmission Towers and Components

Table 2.1.1 System and Line Data

	Description/Details	Unit	Specified	Tendered
1	System Data			
1.1	Nominal Voltage	kV	220	
1.2	Maximum Voltage	kV	245	
1.3	Nominal Frequency	Hz	50	
1.4	1 min. Power Frequency withstand Voltage	kV	395	
1.5	Nominal Current (Single Phase)	A	900	
1.6	Nominal Transmission Capacity Per Circuit	MVA	N/A	
1.7	Rated Lightning Impulse Withstand Voltage	kVP	1,050	
1.8	Number of Conductors Per Phase	No.	1	
2	Line Data			
2.1	220 kV Single Circuit (Single Conductor/Phase) Transmission Line	km	168	
2.2	Average Span Length	m	300	
2.3	Nominal Al. Area of each ACSR “ZEBRA” Conductor	mm^2	400	
2.4	Nominal Area of OPGW	mm^2	71.5	

Table 2.1.2 Design Data

	Description/Details	Unit	Specified	Tendered
1	Load Factors			
1.1	Phase conductors at final maximum working tension based on ultimate strength at maximum working tension	%	70	
1.2	Overhead groundwire at final maximum working tension based on ultimate strength at minimum temperature	%	60	
1.3	Phase Conductors at everyday temperature (25°C) still air, final tension based on ultimate strength	%	Maximum 20	
1.4	Overhead groundwire at everyday temperature (25°C) still air, final tension based on ultimate strength	%	Maximum 20	
2	Working Conditions			
2.1	Minimum Temperature of phase conductors and Overhead groundwire	°C	-25	
2.2	Maximum Temperature of phase conductors and Overhead groundwire	°C	+75	
2.3	Maximum wind velocity (occurring at any temperature)	m/s	41	
2.4	Wind pressure on projected area of tower load combination 1,2	N/m^2	As per mechanical design	
2.5	Wind pressure on projected area of phase conductor and overhead groundwire (on total projected area of the conductor) load combination 1,2	N/m^2	As per mechanical design	
2.6	Wind force on single suspension or tension insulator string load combination 1,2	N/m^2	As per Mechanical design	

Table 2.1.3 Support Types

	Description/Details	Unit	Specified	Tendered
1	Tower Type (Double Circuit)			
1.1	DA (Straight Line)-Suspension Insulator	deg	0 - 2	
1.1.1	Tower Height	m	As Required	
1.1.2	Tower Weight	kg	As Required	
1.2	DB (Angle) – Tension Insulator	deg	0 – 15	
1.2.1	Tower Height	m	As Required	
1.2.2	Tower Weight	kg	As Required	
1.3	DC (Angle) – Tension Insulator	deg	15 - 30	
1.3.1	Tower Height	m	As Required	
1.3.2	Tower Weight	kg	As Required	
1.4	DD (Angle) – Tension Tower	deg	30 - 60	
1.4.1	Tower Height	m	As Required	
1.4.2	Tower Weight	kg	As Required	
1.5	DDM/DDE (Angle, Dead End) – Tension Tower	deg	60 - 90	
1.5.1	Tower Height	m	As Required	
1.5.2	Tower Weight	kg	As Required	

Table 2.1.4 Design Spans

	Description/Details	Unit	Specified	Tendered
1	Basic Span	m	300	
2	Maximum weight span (suspension)	m	As required	
3	Maximum weight span (Tension)	m	As required	
4	Wind Span for all structure	m	As required	
5	Maximum span length as required	m	As required	
6	Minimum spacing between adjacent phase conductors	m	As required	
7	Minimum Shielding angle of OPGW	deg	30	

Table 2.1.5 Minimum Clearances

	Description/Details	Unit	Specified	Tendered
	Minimum clearance between live conductors and ground. Conductor at maximum working temperature in still air at a temperature of 75°C.			
1	Normal ground for pedestrian only	m	7.5	
2	Ground in urban areas normal conditions	m	7.5	
3	Highway / Road Crossing	m	7.5	
4	Power line Crossing at normal condition	m	4.58	
5	Telecommunication Line Crossing	m	3.5	
6	Trees Normal Condition	m	4.0	
7	Navigable waterways	m	20	
8	Live metal to structure and earthed fittings on suspension structures – Reduced wind (10m/sec, +10°C)	mm	1,850	
9	Live metal to structure and earthed fittings on suspension structures – Full wind	mm	700	
10	Clearance between jumper loops and other live metal parts to structure at tension structures in still air	mm	1,850	
11	Clearance between jumper loops and other live metal parts to structure at tension structure during 75° swing	mm	700	

Table 2.1.6 Structural Steel Particulars

	Description/Details	Unit	Specified	Tendered
1	Structural Steel as per DIN 17100			
1.1	Tensile Strength	N/mm^2	370	
1.2	Yield Point	N/mm^2	240	
2	High Strength Steel			
2.1	Tensile Strength	N/mm^2	520	
2.2	Yield Point	N/mm^2	360	
3	High Tensile Steel			
3.1	Tensile Strength	N/mm^2	500	
3.2	Yield Point	N/mm^2	300	
4	Screws and Bolts		DIN 267	
5	Slenderness Ratio (L/R)			
5.1	Tower legs, main members		< 120	
5.2	Bracings		< 200	
5.3	Redundant Members		< 250	
5.4	Tension Members		<400	
6	Tower Member Particulars			
6.1	Minimum member dimensions	mm	50 x 50 x 5	
6.2	Thickness of legs, member in crossarms and in groundwire peaks	mm	6	
6.3	Gusset Plate	mm	6	
6.4	Minimum Stub angle thickness	mm	8	
6.5	Diameters of the Bolt	mm	16	

Table 2.1.7 Line Conductor

	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Conductor Type		ACSR	
3	Conductor Code Name		ZEBRA	
4	Stranding and wire diameter			
4.1	Aluminum	mm	54 / 3.18	
4.2	Steel	mm	7 / 3.18	
5	Nominal Al. Cross sectional Area	mm^2	400	
6	Conductor Diameter	mm	28.62	
7	Ultimate Strength	kg	13,450	
8	Modulus of Elasticity	N/mm^2	69,000	
9	Coefficient of linear expansion	°C	19.30 x 10-6	
10	Standard mass of conductor	Kg/km	1,621	
11	Electrical DC Resistance at 20°C	Ohm/km	0.0674	
12	Standard up jointed length per drum	m	1,600	
13	Applicable Standards		BS 215 Part 2, IEC 60888, 60889, 61089	

Table 2.1.8 Optical Fiber Ground Wire (OPGW)

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Manufacturer's Type and references		ACSR/AW SS-nf 24/48	
3	Fiber Type		Single mode	
4	Constructional Data			
4.1	Optical Unit			
4.1.1	Number of Fiber		24	
4.1.2	Tube Diameter		6.34	
4.2	Armouring			
4.2.1	Aluminum alloy wires	No/mm	3/3.18	
4.2.2	Aluminum clad steel wires	No/mm	6/3.18	
4.3	Cable Overall			
4.3.1	Nominal diameter	mm	12.7	
4.3.2	Weight	kg/m	450	
4.3.3	Cross sectional area	mm^2	71.5	
5	Breaking Load	kN	69	
6	Final modulus of elasticity	kN/mm^2	118	
7	Permanent elongation due to creepage	%	0	
8	Elongation coefficient	/°C	14.4 x 10-6	
9	Rated DC Resistance at 200C	Ohm/km	0.792	
10	Standard length per drum	m	4,000	
11	Minimum bending radius			
11.1	During installation	mm	To be specified	
11.2	After installation	mm	To be specified	
12	Applicable Standards			
12.1	Aluminum alloy wires		IEC 60104 type A	
12.2	Aluminum clad steel wires		IEC 61232	
12.3	Cable Construction		IEC 61089	
12.4	Optical Unit		ITU-T-G 652	

Table 2.1.9 Termination Kit for Optical Fiber Ground Wire (OPGW)

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Manufacturer's Type and references		ACSR/AW SS-nf 24/48	
3	Fiber Type		Single mode	
4	Constructional Data			
4.1	Optical Unit			
4.1.1	Number of Fiber		24	
4.1.2	Tube Diameter		5.5	
4.2	Sheath and physical characteristics			
4.2.1	Cable components		all dielectric	
4.2.2	Filling compound		to be specified	
4.2.3	Inner sheath material		to be specified	
4.2.4	Inner sheath diameter	mm	to be specified	
4.2.5	Water-blocking tape		to be specified	
4.2.6	Outer sheath material		to be specified	
4.2.7	Nominal diameter	mm	to be specified	
4.3	Minimum bending radius			
4.3.1	During installation	mm	To be specified	
4.3.2	After installation	mm	To be specified	
4.4	Maximum Tension			
4.4.1	Maximum pulling Tension	N	To be specified	
4.4.2	Maximum installation load	N	To be specified	
5	Applicable Standards		ITU-T-G 652, 60104 type A, 61232, 61089, 60793, 60794, ASTM-D 1248, 1765	
Note : The termination, splices etc. kit shall be matched the OPGW cable in shape and fiber optic characteristics.				

Table 2.1.10 Tension Insulator (Composite Long Rod) Set

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Manufacturer's Type and references		IEC HT- Silicon Rubber	
3	Insulator Type		Composite Long Rod	
4	Normal Voltage	kV	220	
5	Maximum Voltage	kV	245	
6	System Frequency	Hz	50	
7	Rated impulse withstand voltage (Peak)	kV	1,050	
8	Rated 1 min power frequency withstand voltage (Peak)	kV	460	
9	Minimum Mechanical Failing Load for fittings and Insulators	kN	300	
10	Outside diameter of unit	mm	100	
11	Minimum creepage distance	mm/kV	25	
12	Minimum protective leakage path	%	To be specified	
13	Applicable standard		DIN 48013, IEC 60016, 60305, 60430,060815	

Table 2.1.11 Suspension Insulator (Composite Long Rod) Set

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Manufacturer's Type and references		IEC HT- Silicon Rubber	
3	Insulator Type		Composite Long Rod	
4	Normal Voltage	kV	220	
5	Maximum Voltage	kV	245	
6	System Frequency	Hz	50	
7	Rated impulse withstand voltage (Peak)	kV	1,050	
8	Rated 1 min power frequency withstand voltage (Peak)	kV	460	
9	Minimum Mechanical Failing Load for fittings and Insulators	kN	160	
10	Outside diameter of unit	mm	100	
11	Minimum creepage distance	mm/kV	25	
12	Minimum protective leakage path	%	To be specified	
13	Applicable standard		DIN 48013, IEC 60016, 60305, 60430,060815	

Table 2.1.12 Tension Clamps for "ZEBRA" Conductors

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		Compression	
3	Material			
3.1	Body		corrosion-resistant high-strength aluminum alloy (AlMgSi), drop-forged	
3.2	Screw		steel, hot-dip galvanized	
4	Cross section of conductor	mm²	400	
5	Applicable standard(s)		DIN 48204	

Table 2.1.13 Suspension Clamps for ACSR "ZEBRA" Conductors

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		to be specified	
3	Material			
3.1	Body		corrosion-resistant high-strength aluminum alloy (AlMgSi), drop-forged	
3.2	Screw		steel, hot-dip galvanized	
4	Cross section of conductor	mm²	400	
5	Applicable standard(s)		DIN 48204	

Table 2.1.14 Repair Sleeves for ACSR “ZEBRA” Conductors

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		compression	
3	Body Material		compression type, of material which is best suitable for the con-ductor material	
4	Cross section of conductor	mm²	400	
5	Applicable standard(s)		DIN 48204	

Table 2.1.15 Mid span Joint for ACSR “ZEBRA” Conductors

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		Compression type	
3	Body Material		corrosion-resistant, high-strength aluminum alloy (AlMgSi)	
4	Drop – forget screw		Hot dip galvanized steel	
4	Cross section of conductor	mm²	400	
5	Applicable standard(s)		DIN 48204	

Table 2.1.16 Stockbridge Vibration Dampers for ACSR “ZEBRA” Conductors

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		To be specified	
3	Material			
3.1	Mass of vibration damper:		forged steel or malleable cast iron	
3.2	Spring element		hot-dip galvanized steel wires	
3.3	Clamps		corrosion-resistant , high-strength aluminum alloy (AlMgSi), drop-forged	
3.4	Screw		steel, hot-dip galvanized	
4	Cross section of Conductor	mm²	400	
5	Applicable standard(s)		DIN 48204	

Table 2.1.17 Stockbridge Vibration Dampers for OPGW

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		To be specified	
3	Material			
3.1	Mass of vibration damper:		forged steel or malleable cast iron	
3.2	Spring element		hot-dip galvanized steel wires	
3.3	Clamps		corrosion-resistant , high-strength aluminum alloy (AlMgSi), drop-forged	
3.4	Screw		steel, hot-dip galvanized	
4	Cross section of OPGW	mm^2	71.5	
5	Applicable standard(s)		DIN 48204	

Table 2.1.18 Materials for Tower Grounding

Sr. No.	Description/Details	Unit	Specified	Tendered
1	Manufacturer		To be specified	
2	Type		To be specified	
3	Material			
3.1	Ground Rods		To be specified	
3.2	Galvanized steel angle		To be specified	
3.3	Copper / Galvanized steel ground wire	mm^2	48/Cu, 100/Fe	
3.4	Connection of ground wire electrode and stub angle		To be specified	

Table 2.1.19 Foundation Application Schedule

Sr. No.	Foundation Type	Soil Description
1	Foundation Type – I Spread Footing with undercut	Soil Capable of being undercut such that footing concrete is placed against undisturbed soil. Bearing capacity 1.5 kg/cm2 and assume cone earth 30°. Cohesive material – Very stiff clay requiring picking for removal. A fresh sample which can't be molded by finger pressure and intended by thumb. Blow count over 10. Granular material – Very dense cemented gravel. Difficult to excavate by shovel alone. Relative density over 75%. Blow count over 20.
2	Foundation Type – II Spread Footing	Soil Capable of being excavated with vertical wall. Bearing capacity 1.0 kg/cm2 and assume cone earth 20° Cohesive material – Stiff clay with some silt and sand. Not readily excavated by shovel alone. Can't be molded by finger pressure and intended by thumb. Blow count 8 - 10. Granular material – Compacted sand. Some silt and gravel. Difficult to excavate by shovel alone. Relative density over 60%. Blow count 10-20
3	Foundation Type – III Spread Footing	Soil Capable of being excavated without appreciable sloughing. Bearing capacity 0.5 kg/cm^2 and assume cone earth 10° Cohesive material – Soft to medium clay. Some silt and sand. Can be excavated by shovel alone and molded by finger pressure. Blow count 4 to 8. Granular material – Loose to medium sand and silt. Easily excavated by shovel alone and molded by medium finger pressure. Blow count 4-10
4	Rock Foundation	Soil which cannot be excavated using normal tools and required chiseling, drilling and blasting. These include hard sand stone quartzite, granite, basalt, hard marble etc.

Table 2.1.20 Inspection Tests at Manufacturer's Plant

Sr. No.	Description	Standards
1	Rolled steel Angles and bolts	
1.1	Tensile strength test and chemical analysis, zinc coating test	Steel mill and factory certificates
1.2	Full scale tower load test to destruction	IEC 60652
2	Insulators	
2.1	Temperature cycle test, mechanical failing load test	IEC 61109
2.2	Porosity test, continuity of zinc coating	BS137
2.3	Electrical test on complete insulator strings	ANSI C-29.1
3	Insulator Fittings	
3.1	Routine and sample mechanical tests	IEC 61109
3.2	Galvanizing Tests	BS 729
4	Clamps and Joints	
4.1	Mechanical and electrical type tests, galvanizing and mechanical routine tests	BS 3288, BS 729, ISO, IEC 61109
5	Dampers	
5.1	Fatigue Resistance Test	
5.2	Clamp slippage resistance test	
5.3	Galvanizing test	ISO, BS 729
6	Line Conductor and OPGW	
6.1	Mechanical test, resistivity test, ultimate tensile strength test	IEC 209, BS 2627

The Employer's representatives will inspect and witness the test of tower and other material at manufacturer's plant. All expenses related to the inspection and witness test of tower structure, conductor, OPGW, insulator and hardware and fittings shall be borne by the Contractor.

The number of inspectors for testing different items of equipment and material at manufacturer's plant shall be as follows:

Sr. No.	Description	No. of Inspector	No. of Visit
1	Tower type Test to destruction (for each type of Tower)	Employer four (4) + Employer's Representative one (1)	Five (5)
2	Conductor Testing	Employer four (4) + Employer's Representative one (1)	One (1)
3	OPGW, Termination, Splicing, Testing	Employer four (4) + Employer's Representative one (1)	One (1)
4	Insulators Testing	Employer four (4) + Employer's Representative one (1)	One (1)
5	Hardware and Fittings Testing	Employer four (4) + Employer's Representative one (1)	One (1)

2.2 Substations and Components

Table 2.2.1 220kV Circuit Breaker

Description/Details	Unit	Specified	Tendered
220kV Circuit Breaker:			
Manufacturer			
Manufacturer's type and reference			
Number of poles		3	
Class		Outdoor	
Rated lightning impulse withstand voltage between terminals and earth	kV	1,050	
Rated 1 minute power-frequency withstand voltage to earth	kV	460	
Rated normal current – busbar, transformer, line bay	A	1,600 – bus bar, 1,250 transformer bay, 1,250 line bay	
Rated line-charging breaking current	A		
Rated cable charging breaking current	A		
Rated small inductive breaking current	A		
Rated single capacitor bank breaking current	A		
Rated inrush capacitor bank making current	A		
Rated short-circuit breaking/making current	kA	40	
Rated out-of-phase breaking current	A		
First-pole-to-clear factor			
Rated operation sequence		O-0.3s-CO-3m-CO	
Rated duration of short circuit	s	3	
Rated total breaking time	ms		
Rated total closing time	ms		
Type of arc quenching medium		SF6	
Type of stored energy medium		Motor spring	
Voltage for operation device	VDC	220	

Table 2.2.2 220kV Disconnectors

Description/Details	Unit	Specified	Tendered
220kV Disconnector:			
Manufacturer			
Manufacturer's type and reference			
Rated voltage	kV	245	
Rated short-circuit withstand current, 3s	kA	40	
Rated peak withstand current	kA	50	
Rated lightning impulse withstand voltage			
• to earth and between poles	kV	1,050	
• across open pole Rated 1 min. power-frequency withstand voltage	kV	1,200	
• to earth and between poles	kV	460	
• across open pole	kV	530	
Rated normal current- busbar, transformer, line bay	A	1,600, 1,250, 1,250	
Creepage distance	mm		
Voltage for operation device	VDC	220	
Earthing switch			
Maker's name			
Maker's type and reference			
Rated voltage	kV	245	
Rated short-circuit withstand current, 1s	kA	20	
Rated peak withstand current	Ka	50	
Rated lightning impulse withstand voltage			
• to earth and between poles	kV	1,050	
• across open pole	kV	530	

Table 2.2.3 220kV Voltage Transformers

Description/Details	Unit	Specified	Tendered
220 kV Voltage Transformers:			
Manufacturer			
Manufacturer's type and reference			
Ratio		220kV/√3, 110V/√3, 110V/√3	
Rated Output, Metering/Protection	VA	100/100	
Class, Metering/Protection		0.2/3P	
Type		Capacitive	

Table 2.2.4 220kV Current Transformers

Description/Details	Unit	Specified	Tendered
220kV Current Transformers: Line Bay, Transformer Bay and Bus Coupler			
Manufacturer			
Manufacturer's type and reference			
Rated voltage	kV	245	
Core 1 & 2 characteristics		200-500-800-1200/1A, Class PX, Vk=1500V, Rc<6Ω, Ie<25mA	
Core 3 & 4 characteristics		1200-2400/1A, Class PX, Vk=1500V, Rc<12Ω, Ie<50mA	
Core 5 characteristics		200-500-800-1200/1A, Class 0.2, 25VA	
220kV Current Transformer: Transformer Bay			
Manufacturer			
Manufacturer's type and reference			
Rated voltage	kV	245	
Core 1 & 2 characteristics		10-20-40-80/1A, Class PX, Vk=1500V, Rc<6Ω, Ie<25mA	
Core 3 & 4 characteristics		10-20-40-80/1A, Class PX, Vk=1500V, Rc<6Ω, Ie<50mA	
Core 5 characteristics		10-20-40/1A, Class 0.2, 15VA	

Table 2.2.5 220kV Surge Arrestors

Description/Details	Unit	Specified	Tendered
220kV Surge Arresters:			
Manufacturer			
Manufacturer's type and reference		ZnO type	
Rated voltage (Ur IEC 60099-4)	kV rms	198	
Class		3	
Pressure relief class	kA	10	
Temporary Over Voltage (TOV) 1s	kV rms	229	
Creepage	Mm	6336	
Front of wave, eq residual voltage at 10kA 1/5:s	kV		
Residual voltages 8/20:s wave at 5/10/20kA	V	443/466/512	

Table 2.2.6 220/20kV 4MVA Transformer

Description/Details	Unit	Specified	Tendered
Transformer 220/20kV			
Manufacturer			
Manufacturer's type and reference			
Rated power (at Substation location)	MVA	4	
Rated voltage, primary winding	kV	220 ± 6x1.25 %	
Rated voltage, secondary winding	kV	24	
No load losses at rated voltage*			
No load losses at 110 % rated voltage	kW		
Load losses at rated voltage and power*	kW	Refer to Sub-Clause 2.4.2.3	
Impedance voltage	%	10	
Magnetic flux density	Tesla	1.55	
Top oil temperature	°C	55	
Hot spot / winding	°C	60	
Impulse withstand voltage, primary winding	kV	1,050	
Impulse withstand voltage, secondary winding	kV	550	
Power frequency withstand voltage, primary winding	kV	480	
Power frequency withstand voltage, secondary winding	kV	50	
Net weight	kg		
Weight of oil	kg		
Total weight	kg		
Overall dimensions (length x width x height)	mm		
Transport dimensions (length x width x height)	mm		
Noise level at 2.0 m distance (DIN 45 635)	dB(A)		
Vector Group		YNyn0d11	
On-load tap changer (OLTC)			
Maker's name			
Maker's type test and reference		IEC 60214 and IEC 60542	
Rated Current	A		
Number of steps		15	
Contact life (operations)		>200,000	
Bushings – Primary			
Manufacturer			
Type		IEC 60137	
Lightning impulse level	kV		
Minimum creepage distance	mm		
Bushings – Secondary			
Manufacturer			
Type		IEC 60137	
Lightning impulse level	kV		
Minimum creepage distance	mm		

Table 2.2.7 20kV Metalclad Switchgear

Description/Details	Unit	Specified	Tendered
20kV Metalclad Switchgear			
Name of manufacturer			
Country of manufacture			
Type of Construction		Metalclad	
Location		Indoor	
Standard	IEC	62271-200	
Degree of Protection	IEC	IP54	
Rated frequency	Hz	50	
Rated voltage	kV	24, rms	
Impulse withstand voltage (dry)	kV	125, peak	
One minute power frequency withstand	kV	55 ,rms	
Short time withstand current(3 secs)	kA	16,rms	
Busbar current rating	A	800	
Busbar material		Copper	
Weight of complete unit	kg		
Overall width	mm		
Overall height	mm		
Overall length	mm		
Circuit Breakers			
Breaking medium	Vacuum/SF6		
Rated current	A	630	
Breaking capacity	kA	25,rms	
Making capacity	kA	62.5,peak	
Operating mechanism		spring	
Spring charging motor voltage	V	230,ac,1 phase	
Spring charging motor rating	W		
Closing coil voltage	V	220 VDC	
Closing coil rating	A		
Tripping coil voltage	V	220 VDC	
Tripping coil rating	A		
20kV Surge Arresters:			
System Voltage (Um)	kV	24	
Rated voltage (Ur IEC 60099-4)	kV rms	24	
Class			
Pressure relief class	kA		
Temporary Overvoltage (TOV) capability (1s)	kV	24	
Minimum Creepage	Mm		
Residual voltages 8/20 μs wave at 5/10/20 kA	kV peak		
Voltage Transformers			
Primary voltage	V	20,000/√3	
Secondary voltage	V	110/√3	
Tertiary voltage	V	110/√3	
Output secondary	VA	100	
Output tertiary	VA	100	
Secondary class	class	.2	
Tertiary class	class	3P	
Type		Inductive	
Current Transformers			
Ratio - incomer		100/50/25/1	

Description/Details	Unit	Specified	Tendered
Ratio - feeder		50/25/1	
Protection		5P10/X	
Metering		.5	
Burden incomer protection	VA		
Burden feeder protection	VA		
Burden incomer metering	VA		
Burden feeder metering	VA		

Table 2.2.8 Control / Protection Equipment

Description/Details	Unit	Specified	Tendered
Relay/Control Boards:			
Manufacturer			
Manufacturer's type and reference		IEC 60529	
Protection class		IP43	
Overall Dimensions, h x w x d	mm		
Energy Meters			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.8.7	
Type of kWh meters, class	0.2		
Type of kVAr meters, class	0.5		
Relay Protection			
Manufacturer			
Manufacturer's type and reference			
110 kV Feeder Protection			
Further information			
The Bidder shall include herein:			
(a) Drawings showing the design of control boards.			
(b) Description of relays and other control equipment.			
(c) Location and types of outdoor lighting appliances			

Table 2.2.9 Batteries and Rectifiers

Description/Details	Unit	Specified	Tendered
220V Batteries:			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.8.14	
Capacity, 10h discharge	Ah		
Capacity, 1h discharge	Ah		
Maximum charging current	A		
Number of cells			
Overall dimensions, h x b x d	mm		
Floating charge voltage	V	100% x U_N	
Quick charge 1 voltage	V		
Quick charge 2 voltage	V		
220V Rectifiers:			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.8.14	
Maximum current DC	A		
Charging time	h	12	
Overall dimensions, h x b x d	mm		
48V Battery:			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.8.14	
Capacity, 10h discharge	Ah		
Capacity, 1h discharge	Ah		
Maximum charging current	A		
Number of cells			
Overall dimensions, h x b x d	mm		
Floating charge voltage	V	100% x U_N	
Quick charge 1 voltage	V		
Quick charge 2 voltage	V		
48V Rectifiers:			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.8.14	
Maximum current DC	A		
Charging time	h	12	
Overall dimensions, h x b x d	mm		

Table 2.2.10 Cables

Description/Details	Unit	Specified	Tendered
Cables:			
For each type of cable the following information shall be attached with the Bid.			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.8.15	
Electrical Data:			
- Rated voltage			
- Highest system voltage			
- Insulation level	kV		
Constructional Data:			
- Reference standard according to IEC			
- Conductor			
- Insulation			
- Laying up			
- Metallic sheath			
- Overall sheath			
- Weight per km			
- Core identification system			
Cable Racks and Trenches:			
Constructional data for cable racks and accessories shall be attached with the Tender.			
For each type of cable trench a principal construction and disposition of cables and racks shall be attached with the Tender			

Table 2.2.11 Auxiliary Power Transformer 20/0.4kV

Description/Details	Unit	Specified	Tendered
Auxiliary Power Transformer 20/0. kV:			
Manufacturer			
Manufacturer's type and reference		Refer to Section 2.4.2.2	
Type			
Nº of phases		3	
Standard	IEC	60076	
Continuous rated output		100	
Nominal ratio of transformation at no load			
Vector group		Dyn11	
Rated frequency	Hz	50	
Voltage Ratio	V	20,000/415-240	
Type of tap-changer		Off-voltage	
Total range of transformation ratio (on 20 kV)	%	+5% +2.5% 0% -2.5% -5%	
Impulse withstand voltage of HV winding	kV	125	
Impulse withstand voltage of LV winding	kV		
Maximum flux density of core			
Maximum flux density of Yoke			
Magnetizing current	A		
No-load loss at normal ratio at 75 °C*	kW		
Load loss at normal ratio at 75 °C*	kW		
Total load loss at normal ratio at 75°C	kW		
Efficiency at normal ratio and unity power factor	%		
Efficiency at normal ratio and power factor of 0.8	%		
Resistance of winding at 75°C HV winding	Ohm		
Resistance of winding at 75°C LV winding	Ohm		
Transformer type (indoor / Outdoor)		Outdoor	
Type of Cooling		ONAN	
Insulation			
Hermetically sealed	Yes/No	Yes	
MV bushing type		Outdoor plug in 200A	
LV bushing type		Palm	
Ambient maximum temperature rise	°C		
Winding temperature rise (maximum)	°C		
Type of HV winding	°C		
Type of LV winding			
Total oil required	liter		
Acoustic sound level	dB		
Exterior finish		Hot dip galvanized	
Dimension of fully assembled transformer			
- Width	mm		
- Depth	mm		
- Height	mm		
Dimension for transportation			
- Width	mm		
- Depth	mm		
- Height	mm		
Weight of core and winding	kg		
Weight of fully assembled transformer	kg		

Table 2.2.12 MV Cable

Description/Details	Unit	Specified	Tendered
MV Cables			
Manufacturer			
Manufacturer's Code Nº			
Nominal voltage rating	kV	11.5/20 kV (24 kV)	
Number and nominal size of core	mm^2	3x240 1x400	
Stranding - aluminum	mm		
Thickness of conductor shield	mm	1.0	
Thickness of XLPE insulation	mm	5.5	
Size of insulation shield			
- semi-conducting thickness	mm		
- copper cross-section	mm^2		
Thickness of PVC sheath	mm		
Stranding-armor	mm		
Maximum Conductor temp. rating	°C	90	
Maximum current rating	A		
Conductor resistance	ohm/km		
Conductor impedance	ohm/km		
Conductor inductance	mH/km		
Conductor capacitance	μF/km		
Short circuit rating			
t = 0.1 seconds	kA	16	
t = 0.2 seconds	kA		
t = 0.5 seconds	kA		
t = 1.0 seconds	kA		
Cable weight	kg/km		
Minimum bending radius	mm		
Maximum drum wound lengths	m	>500	
Maximum Pulling Tension	kN	3,000	
Ultimate Tensile strength	kN		

Table 2.2.13 MV Cable Accessories

Description/Details	Unit	Specified	Tendered
Cable Termination Kits			
Manufacturer			
Manufacturer's Code Nº			
Type			
Nominal voltage rating	kV	20/24	
Nominal size of cable	mm^2	240 400	
Number of cores		3 1	
Type of conductor		AAC	
Material of inner voltage stress relief			
Material of outer insulation			
Non-tracking per ASTM D2302			
Overall dimensions	mm		
Weight	kg		

3.0 Drawings, Schedules, Maps

A. Contract 1A 220kV T/L Tap, Line Routing and Profile (Lot 1)

1. E-301 Transmission Line, Legend, Notes and Abbreviations
2. E-301 Transmission Line Routing Plan
3. E-301 Transmission Line Profile View
4. E-301 Transmission Line Tap Detail
5. E-301 Transmission Line Tap Detail 2 West View

B. Contract 1B SS General Arrangement and One-Line Diagram (Lot 2)

1. E-401 Substation Legend
2. E-402 Substation General Arrangement
3. E-403-A Substation One Line Diagram 220/20kV
4. E-403-B Substation One Line Diagram 220/20kV

C. Contract 1C 20kV Sub-Transmission Line Routing, Modifications and One-Line Diagram (Lot 3)

1. E-201 MV Work, Legend, Notes and Abbreviations
2. E-202 MV Work, 20kV Sub-Transmission Line Routing Plan
3. E-202-A MV Work, 20kV Sub-Transmission Line Routing Plan
4. E-202-B MV Work, 20kV Sub-Transmission Line Routing Plan
5. E-202-C MV Work, 20kV Sub-Transmission Line Routing Plan
6. E-202-D MV Work, 20kV Sub-Transmission Line Routing Plan
7. E-202-E MV Work, 20kV Sub-Transmission Line Routing Plan
8. E-202-F MV Work, 20kV Sub-Transmission Line Routing Plan
9. E-202-G MV Work, 20kV Sub-Transmission Line Routing Plan
10. E-202-H MV Work, 20kV Sub-Transmission Line Routing Plan
11. E-203 MV Work, MV Substation Modifications Plan
12. E-204 MV Work, MV S/S Modifications One-Line Diagram

D. Informative Earthquake Maps

1. DWG ESDIP TL 04 01 : Seismicity of the Afghanistan Region
2. DWG ESDIP TL 04 02 : Earthquake Density Map
3. DWG ESDIP TL 04 03 : Seismic Hazard Map

Section A

Contract 1A 220kV T/L Tap, Line Routing and Profile (Lot 1)

LEGEND

SYMBOL	DESCRIPTION
⊠	LATTICE TOWER
— - — - — - —	TRANSMISSION CENTERLINE
STR.	TRANSMISSION STRUCTURE
- - - - - - - -	APPROXIMATE CONDUCTOR LOCATION

NOTES:
1. ALL DIMENSIONS ARE APPROXIMATE.
2. TERRAIN INFORMATION NOT PROVIDED. TERRAIN WILL VARY FROM INDICATED.
3. CONDUCTOR AND STRUCTURE ATTACHMENT HEIGHTS ARE APPROXIMATE.

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UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

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SALANG TUNNEL SUBSTATION

TRANSMISSION LINE, LEGEND, NOTES AND ABBREVIATIONS–CONTRACT–1A

SHEET REFERENCE NUMBER: E–301

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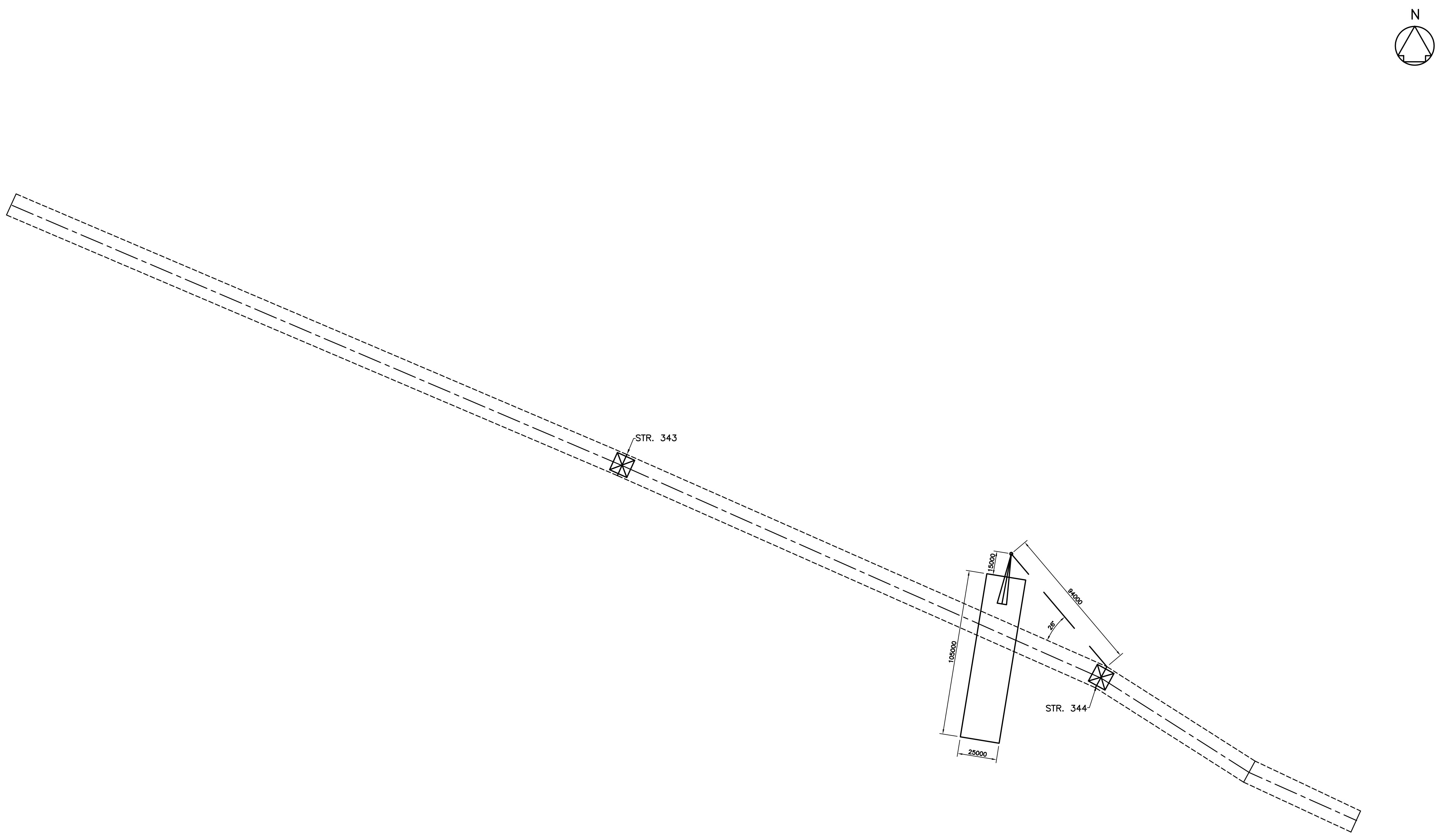

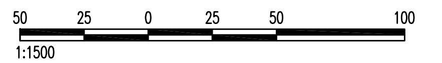

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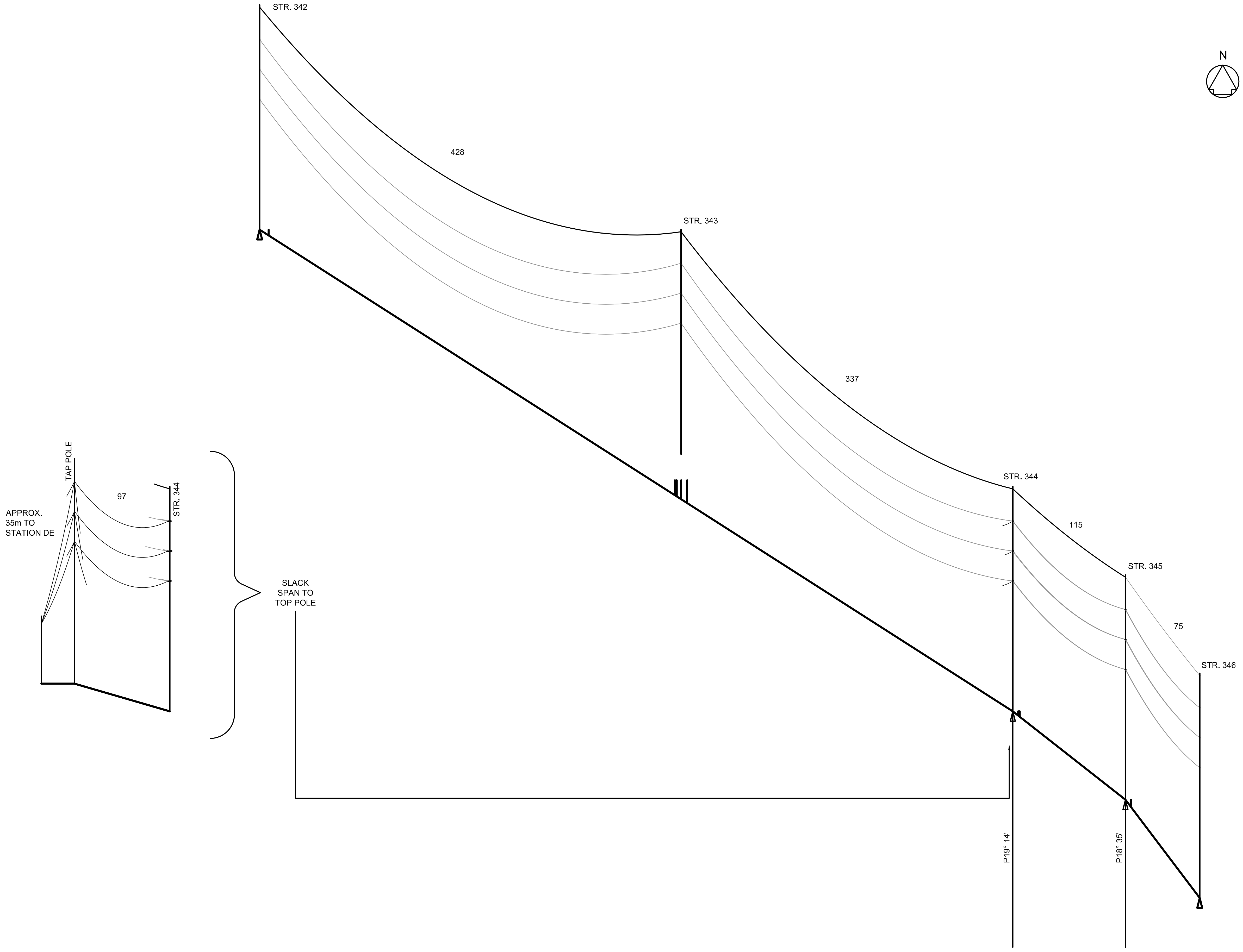
SALANG TUNNEL SUBSTATION

TRANSMISSION LINE ROUTING PLAN CONTRACT-1A

SHEET REFERENCE NUMBER:

E-302-A



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SALANG TUNNEL SUBSTATION

TRANSMISSION PROFILE VIEW CONTRACT-1A

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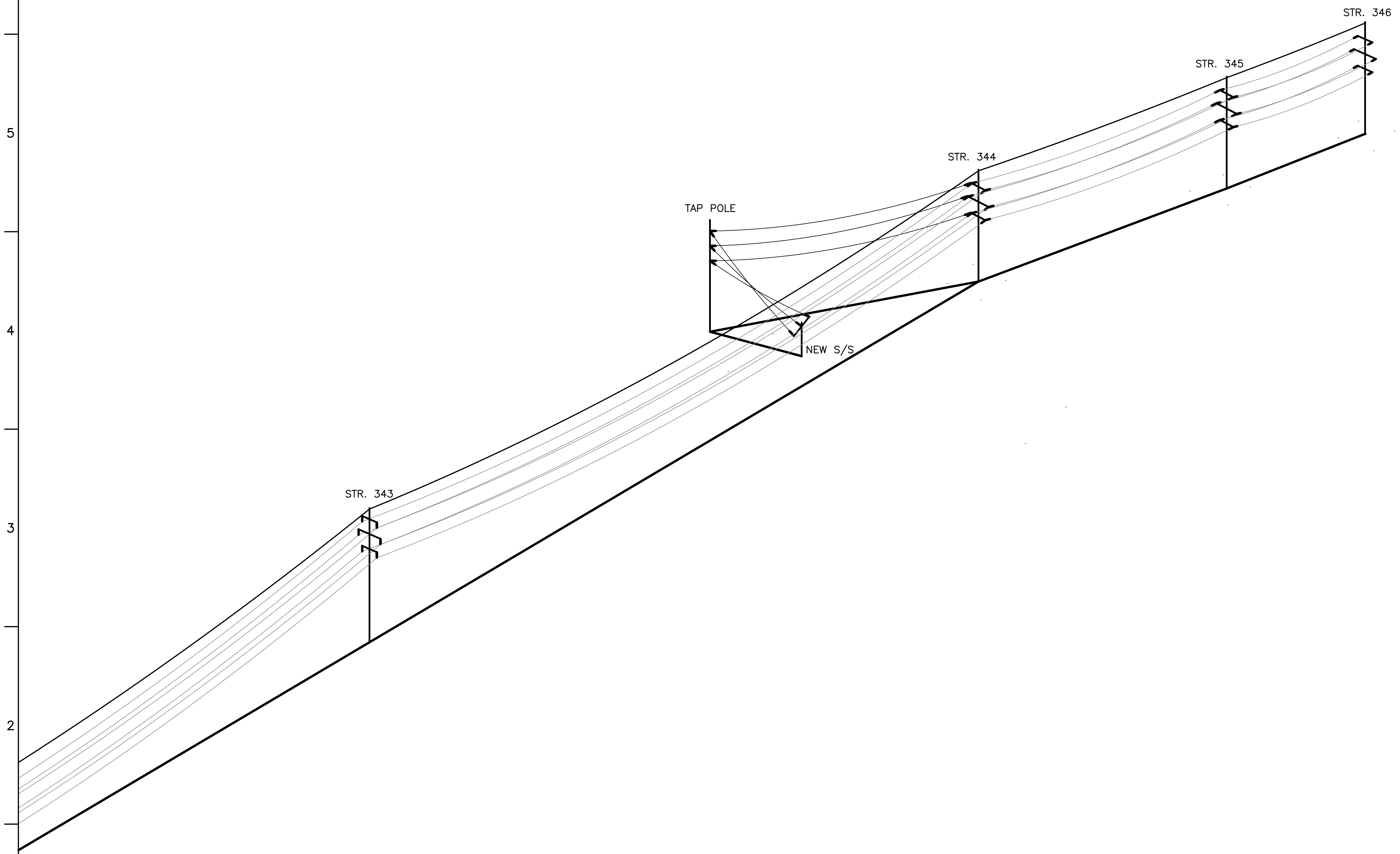

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SALANG TUNNEL SUBSTATION

TRANSMISSION TAP DETAIL 1
EAST VIEW – CONTRACT-1A

SHEET REFERENCE NUMBER:
E-303-A

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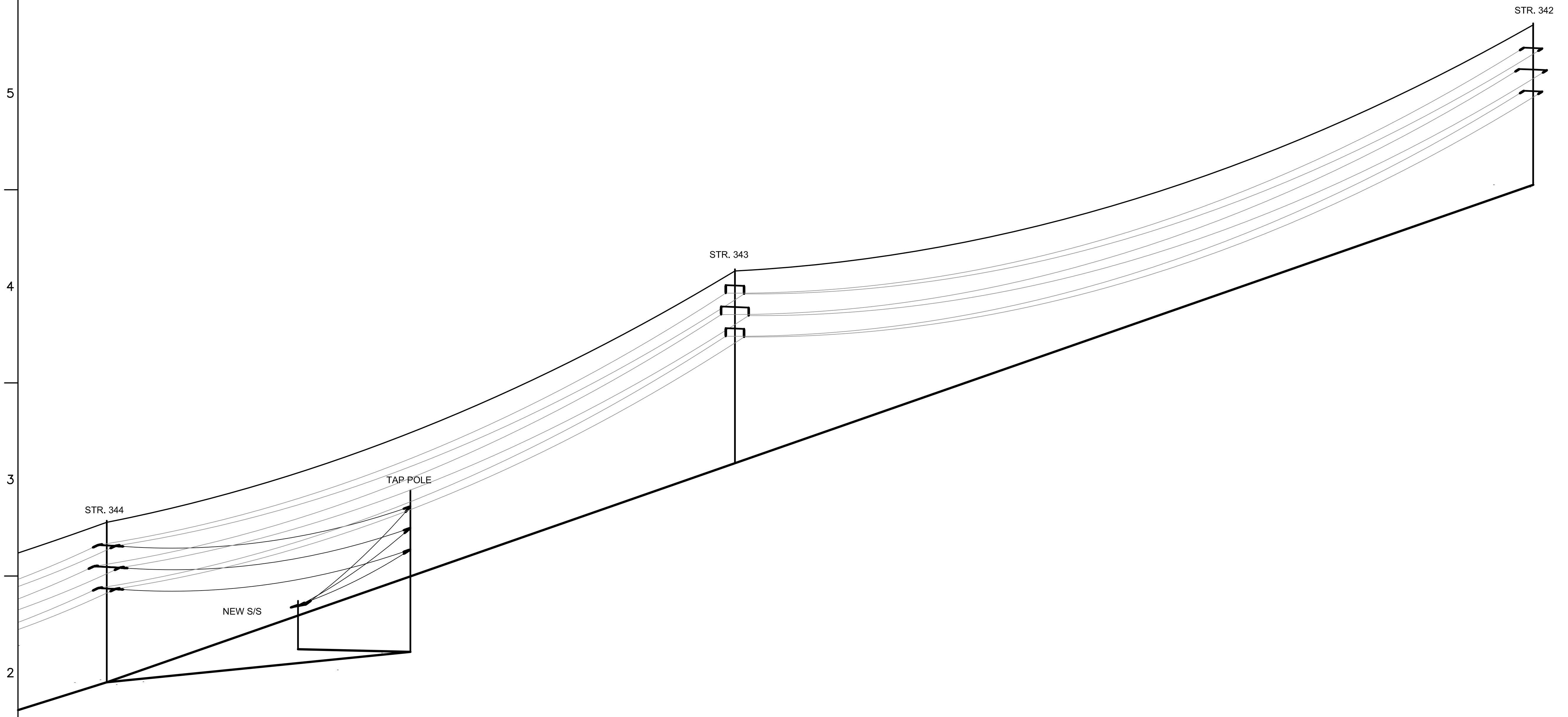

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SALANG TUNNEL SUBSTATION

TRANSMISSION TAP DETAIL 2
WEST VIEW – CONTRACT-1A

SHEET REFERENCE NUMBER:
E-303-B

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Section B

Contract 1B SS General Arrangement and One-Line Diagram (Lot 2)

LEGEND

SYMBOL	DESCRIPTION
	SWITCHGEAR CIRCUIT BREAKER
	AC CIRCUIT BREAKER
	LIGHTNING ARRESOTR (LA) SURGE ARRESTOR (SA)
	TRANSFORMER
	COUPLING CAPACITOR VOLTAGE TRANSFORMER
	FREE STANDING CURRENT TRANSFORMER
	BUSHING MOUNTED CURRENT TRANSFORMER
	DISCONNECT (ISOLATOR) WITH TWO EARTHING SWITCH
	DISCONNECT (ISOLATOR) WITH EARTHING SWITCH
	DISCONNECT (ISOLATOR)
	GROUP OPERATED DISCONNECT
	UNDERGROUND CONDUCTOR WITH TERMINATIONS
XX	PROTECTIVE RELAY/METERING/ELECTRONIC RELAY XX DEDICATED NUMBER
	AUTOMATIC TRANSFER SWTICH
K	KIRK-KEY INTERLOCK
	NOT IN PRESENT SCOPE
	INDICATES FENCE
	CURRENT TRANSFORMER
	CAPACITIVE VOLTAGE TRANSFORMER
	SURGE ARRESTOR
	CIRCUIT BREAKERS (3 PH)
	DISCONNECTOR SWITCH-D.S DISCONNECTOR WITH EARTHING SWITCH-D.S/E.S
	20 kV LIGHTNING ARRESTOR
	20 kV SWITCH

RELAY	21-	DISTANCE RELAY
	50-	INSTANTANEOUS OVERCURRENT RELAY
	51-	TIME OVERCURRENT RELAY
	52-	AC CIRCUIT BREAKER
	64-	GROUND DETECTOR RELAY
	67-	AC DIRECTIONAL OVERCURRENT RELAY
	87T-	TRANSFORMER DIFFERENTIAL PROTECTIVE RELAY
	87B-	BUS DIFFERENTIAL RELAY
ABBREVIATION	LA-	LIGHTNING ARRESTOR
	CT-	CURRENT TRANSFORMER
	Z-	IMPEDANCE RELAY
	CVT-	CAPACITOR VOLTAGE TRANSFORMER

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SALANG TUNNEL SUBSTATION

SUBSTATION LEGEND CONTRACT-1B

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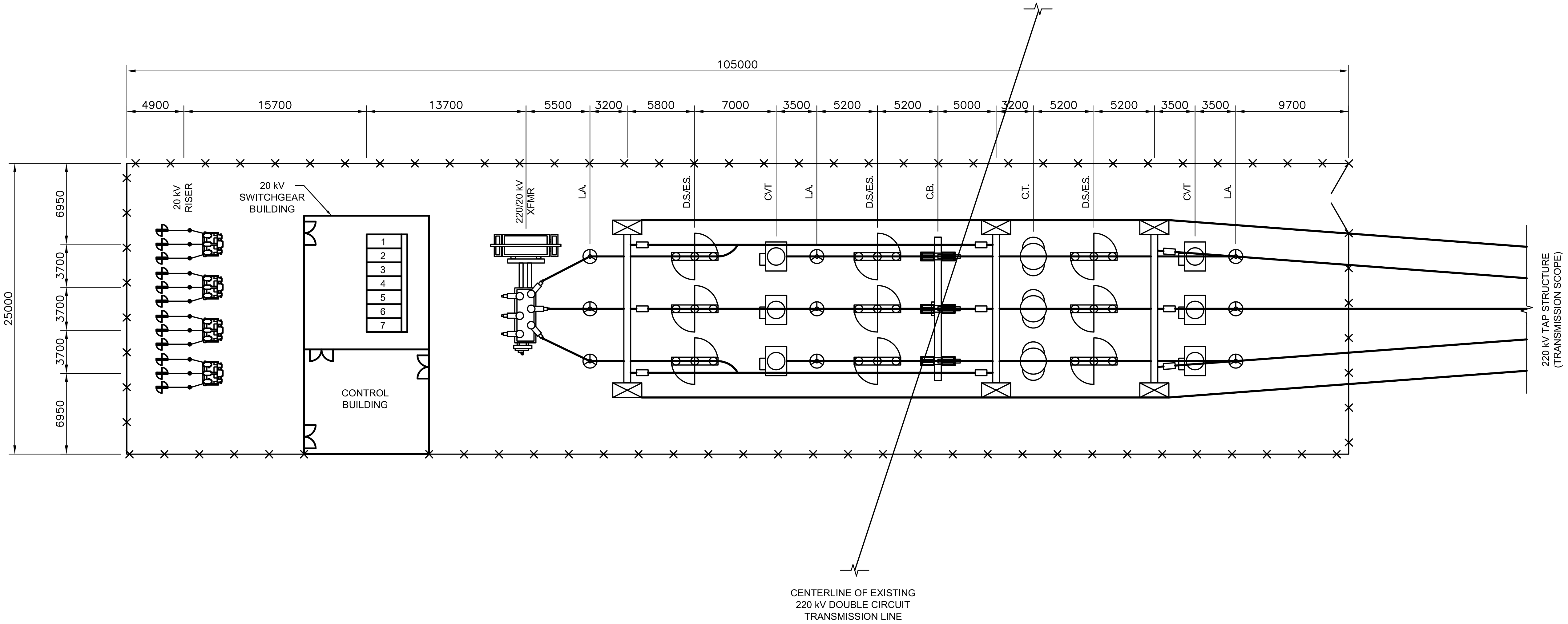

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5 0 5 10 15
1:200

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SALANG TUNNEL SUBSTATION

SUBSTATION GENERAL ARRANGEMENT CONTRACT-1B

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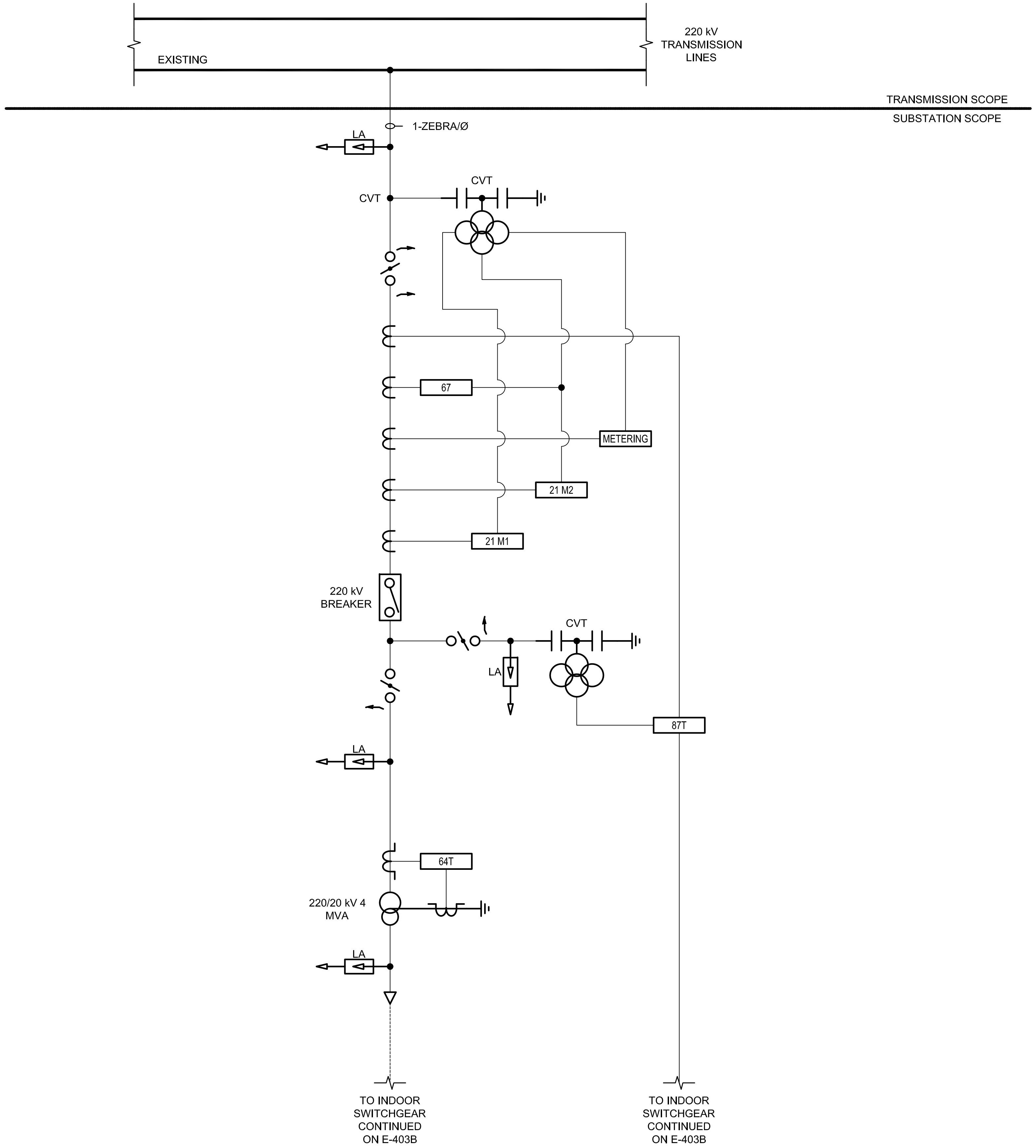
E-402



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SALANG TUNNEL SUBSTATION

SUSBTATION ONE LINE DIAGRAM 220/20kV - CONTRACT-1B

SHEET REFERENCE NUMBER: E-403-A

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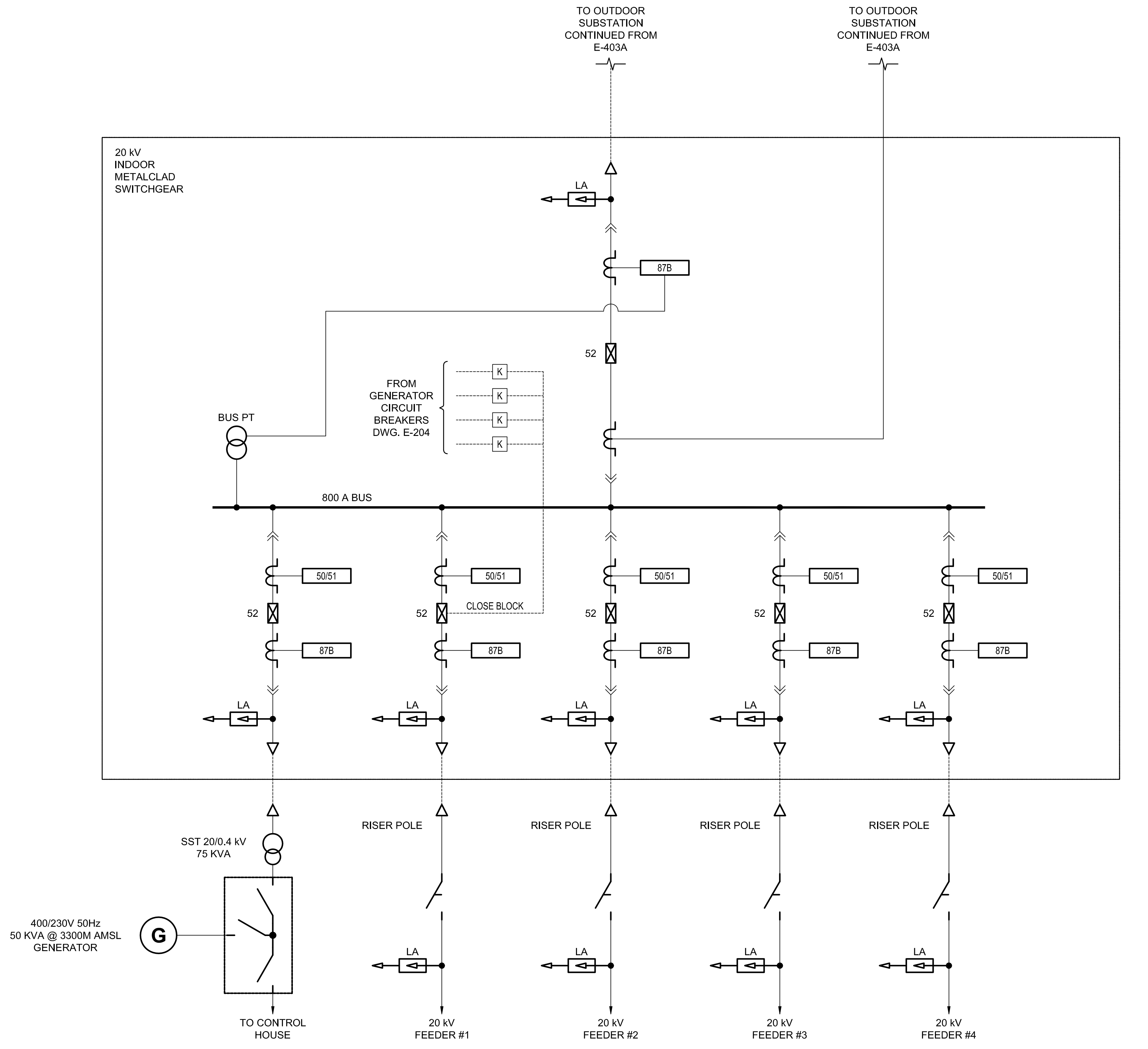

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SALANG TUNNEL SUBSTATION

SUSBTATION ONE LINE DIAGRAM 220/20kV – CONTRACT-1B

SHEET REFERENCE NUMBER: E-403-B

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5 0 5 10 15
1:200

NOTE: A3 SIZE REDUCED TO HALF SCALE.

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Section C

Contract 1C 20kV Sub-Transmission Line Routing, Modifications and One-Line Diagram (Lot 3)

PLAN LEGEND (SITE)

SYMBOL	DESCRIPTION
HH	HANDHOLES
—UE—	EXISTING UNDERGROUND ELECTRICAL
UE	UNDERGROUND ELECTRICAL
UC	UNDERGROUND COMMUNICATION
PB	PULLBOX
O/H	OVER HEAD TRANSMISSION

PLAN LEGEND (MEASURING)

SYMBOL	DESCRIPTION
A	AMMETER
V	VOLT METER
W	WATT METER
M	METER SOCKET
Hz	FREQUENCY METER
φ	PHASE METER
COSφ	POWER FACTOR METER
	SYNCHRONOSCOPE
kWh	KILO WATT–HOUR METER

PROTECTIVE RELAYS

SYMBOL	DESCRIPTION
21	DISTANCE RELAY
27	UNDERVOLTAGE RELAY
50	INSTANTANEOUS OVERCURRENT RELAY
51	TIME OVERCURRENT RELAY
52	AC CIRCUIT BREAKER
59	OVER VOLTAGE RELAY
64	EARTH FAULT RELAY
67	AC DIRECTIONAL OVERCURRENT RELAY
87	DIFFERENTIAL RELAY
89	LINE SWITCH
BB	CHECK –BUS DIFFERENTIAL RELAY

PLAN LEGEND (LIGHTING)

SYMBOL	DESCRIPTION
CKT	LIGHTING FIXTURE
	EXIT SIGN. WALL MOUNT AS INDICATED. LIT FACES AS INDICATED.

PLAN LEGEND (POWER)

SYMBOL	DESCRIPTION
	PANELBOARD
GFI	16A, 250V SHUKO RECEPTACLE GFI SUBSCRIPT GROUND FAULT INTERRUPTER. LABEL RECEPTACLE WITH VOLTAGE, FREQUENCY AND BRANCH CIRCUIT CONNECTED.
CR	CORD REEL
	EQUIPMENT CONNECTION
R	RELAY
J	JUNCTION BOX
T	TRANSFORMER
TYPE A	GROUNDING ROD (MADE ELECTRODE)
SWITCH a	SWITCH,16A,250, UNO
	HOME RUN TO PANELBOARD
	LOAD UNDER OTHER SECTIONS
XXX–## ###	MOTOR
	ROAD

ONE–LINE AND CONTROL SCHEMATIC LEGEND

SYMBOL	DESCRIPTION
	SURGE ARRESTER
	MV DISCONNECT SWITCH
AR - 1	AUTO – RECLOSER WITHOUT DIRECTIONAL BLOCKING
LBS	LOAD BREAK SWITCH
AR - 2	AUTO – RECLOSER WITH DIRECTIONAL BLOCKING
52	REMOVABLE/DRAWOUT CIRCUIT BREAKER
	FUTURE REMOVABLE/DRAWOUT CIRCUIT BREAKER POSITION
	NON–DRAWOUT CIRCUIT BREAKER
	REMOVABLE/DRAWOUT CIRCUIT BREAKER
	DISCONNECT SWITCH (ISOLATOR)
	FUSE
	BUS DUCT
	AUTO TRANSFORMER
G	GENERATOR
	TRANSFORMER 3P VARIABLE COUPLING
	CAPACITIVE VOLTAGE TRANSFORMER
	REACTOR/CHOKE
	CURRENT TRANSFORMER
	PT (POTENTIAL TRANSFORMER)
	TRANSFORMER
XXX	ATS: AUTOMATIC TRANSFER SW MTS MANUAL TRANSFER SW
	FUSED DISCONNECT SWITCH
	DISCONNECT SWITCH
	GROUNDING ELECTRODE SYSTEM, CONNECTION TO GROUND
	HIGH VOLTAGE SWITCH
K	"KIRK–KEY" INTERLOCK CYLINDER
	Y–CONNECTION
	DELTA–CONNECTION
	POT HEAD (INSULATION BETWEEN UNDERGROUND & OH SUBTRANSMISSION)
	POLE
	TOWER

INTERFACE WITH EXISTING EQUIPMENT LEGEND

<E>	EXISTING TO REMAIN
<ER>	EXISTING TO BE REMOVED
<EM>	EXISTING TO BE MOVED
<EL>	EXISTING TO BE LOCATED
<EO>	TO BE PROVIDED BY OTHER BEFORE START OF WORK.

ABBREVIATIONS

A	AMPERE
AFF	ABOVE FINISHED FLOOR
AFG	ABOVE FINISHED GRADE
AHU	AIR HANDLING UNIT
ATS	AUTOMATIC TRANSFER SWITCH
BFG	BELOW FINISHED GRADE
BLDG	BUILDING
C	CONDUIT
CATV	CABLE TELEVISION
CKT	CIRCUIT
CL	CENTER LINE
CND	CONDUCTOR
COR	CONTRACTING OFFICERS REPRESENTATIVE
CT	CURRENT TRANSFORMER
CVT	CAPACITOR VOLTAGE TRANSFORMER
EC	ELECTRICAL CONTRACTOR
EGC	EQUIPMENT GROUNDING CONDUCTOR
EMT	ELECTRICAL METALLIC TUBING
EP	EXPLOSION PROOF
EPO	EMERGENCY POWER OFF
ERH	ELECTRIC RADIENT HEATER
ESS	ELECTRONIC SECURITY SYSTEM
FACP	FIRE ALARM CONTROL PANEL
FO	FIBER OPTIC
GEC	GROUNDING ELECTRODE CONDUCTOR
GES	GROUNDING ELECTRODE SYSTEM
GFE	GOVERNMENT FURNISHED CONTRACTOR INSTALLED
GFI	GROUND FAULT INTERRUPTING
HC	CONTRACTOR RESPONSIBLE FOR HVAC WORK
HP	HORSEPOWER
HPS	HIGH PRESSURE SODIUM
HVAC	HEATING, VENTILATION, AND AIR CONDITIONING
HZ	HERTZ
IDS	INTRUSION DETECTION SYSTEM
kAIC	AMPERE INTERRUPTING CAPACITY IN THOUSANDS
kV	KILOVOLT
kVA	KILOVOLT-AMPERE
kW	KILOWATT
LA	LIGHTNING ARRESTER
LC	LIGHTING CONTACTORS
M	METERS
MCB	MAIN CIRCUIT BREAKER
MFR	MANUFACTURER
MH	MANHOLE
MLO	MAIN LUGS ONLY
MM	MULTIMODE
mm	MILLIMETERS
MTD	MOUNTED
N	NEUTRAL
NEC	NATIONAL ELECTRICAL CODE (NFPA 70)
NIC	NOT IN CONTRACT
P	POLE
PBSS	PUSHBUTTON START/STOP
PET	PROTECTED ENTRANCE TERMINAL
PH, φ	PHASE
RCD	RESIDUAL CURRENT DEVICE
RGS	RIGID GALVANIZED STEEL
RM	ROOM
SIRP	SECURE INTERNET PROTOCOL ROUTING
SM	SINGLEMODE
SN	SOLID NUETRAL
TBB	TELEPHONE BACKBOARD
TTC	TELEPHONE TERMINAL CABINET
TYP.	TYPICAL
UGE	UNDERGROUND ELECTRIC
UNO	UNLESS NOTED OTHERWISE
V	VOLT
W	WATT
WM	WIREMOLD
WP	WEATHERPROOF
W/	WITH
W/O	WITHOUT
XFMR,T	TRANSFORMER
SA	SURGE ARRESTER
MTS	MANUAL TRANSFER SWITCH

DETAIL CALLOUT

REFERENCE DESIGNATION NUMBER
2
E–002 E–008
CURRENT SHEET
DETAIL SHEET LOCATION

DETAIL TITLE

DESIGNATION NUMBER
2
E–002 E–008
DETAIL CALLOUT SHEET
CURRENT SHEET

ELEVATION/SECTION CALLOUT

DESIGNATION NUMBER
A
E–002 E–009
DETAIL CALLOUT SHEET
CURRENT SHEET

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SYMB	DESCRIPTION	DATE	APR
A	CONCEPT	12/11/05	

DESIGNED BY: ML | DATE: 12/12/01 | SUBMITTED BY: TETRA TECH
DWN BY: TW | FILE NO.: E–201
CHK BY:

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A E S P

SALANG TUNNEL SUBSTATION

MV WORK, LEGEND, NOTES AND ABBREVIATIONS–CONTRACT–1C

SHEET REFERENCE NUMBER:

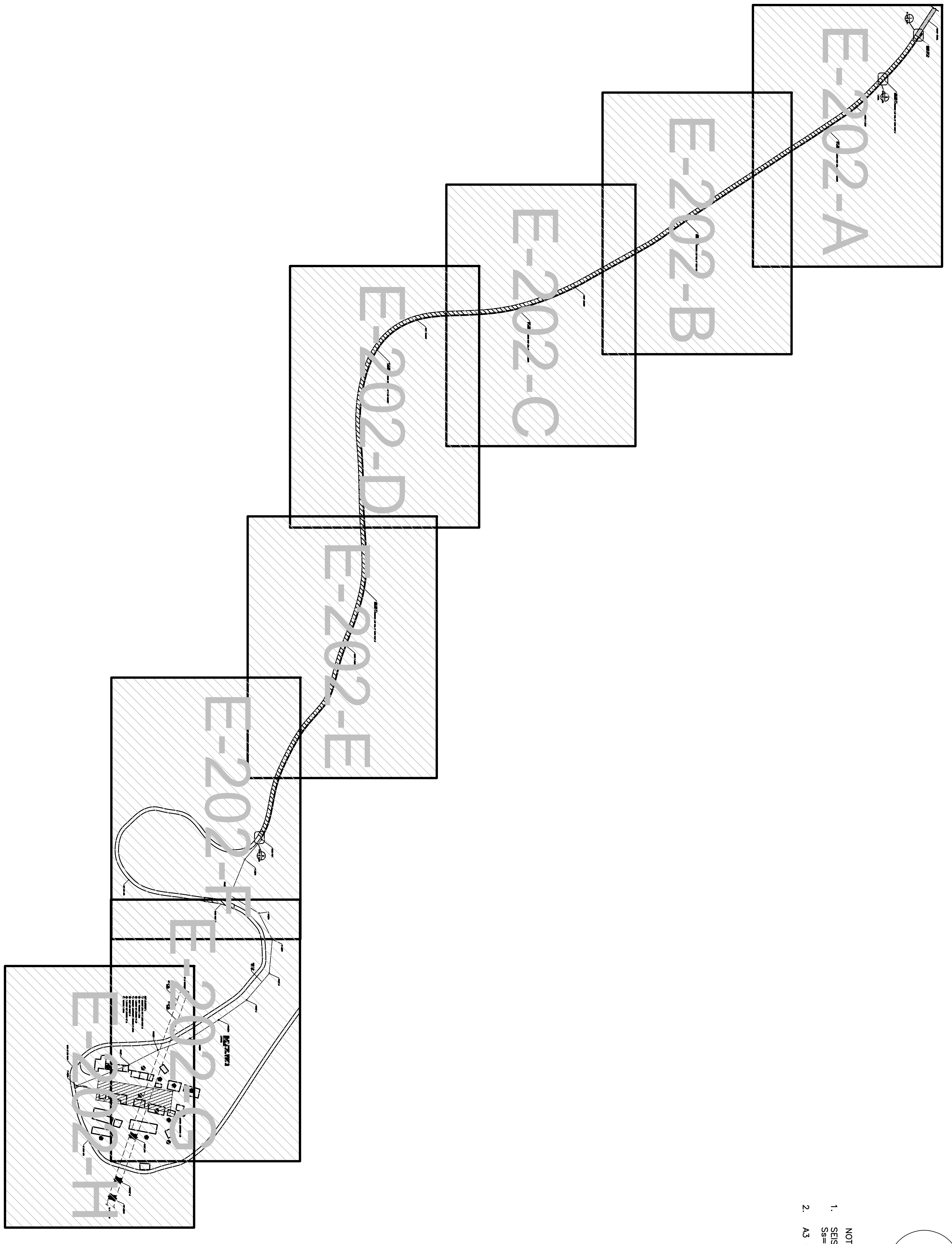
E–201

DRAFT 12/3/2012 9:07 AM

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E202.dwg 12/3/2012 9:08:44 AM Wahidi, Tarik

NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.



1:3000 100 0 100 200

NOTES:

1. SEISMIC PARAMETERS: Ss=1.00g AND S1=0.50g
2. A3 SIZE REDUCED TO HALF SCALE.

N

DRAFT 12/3/2012 9:08 AM

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SHEET REFERENCE NUMBER:	E-202

SALANG TUNNEL SUBSTATION

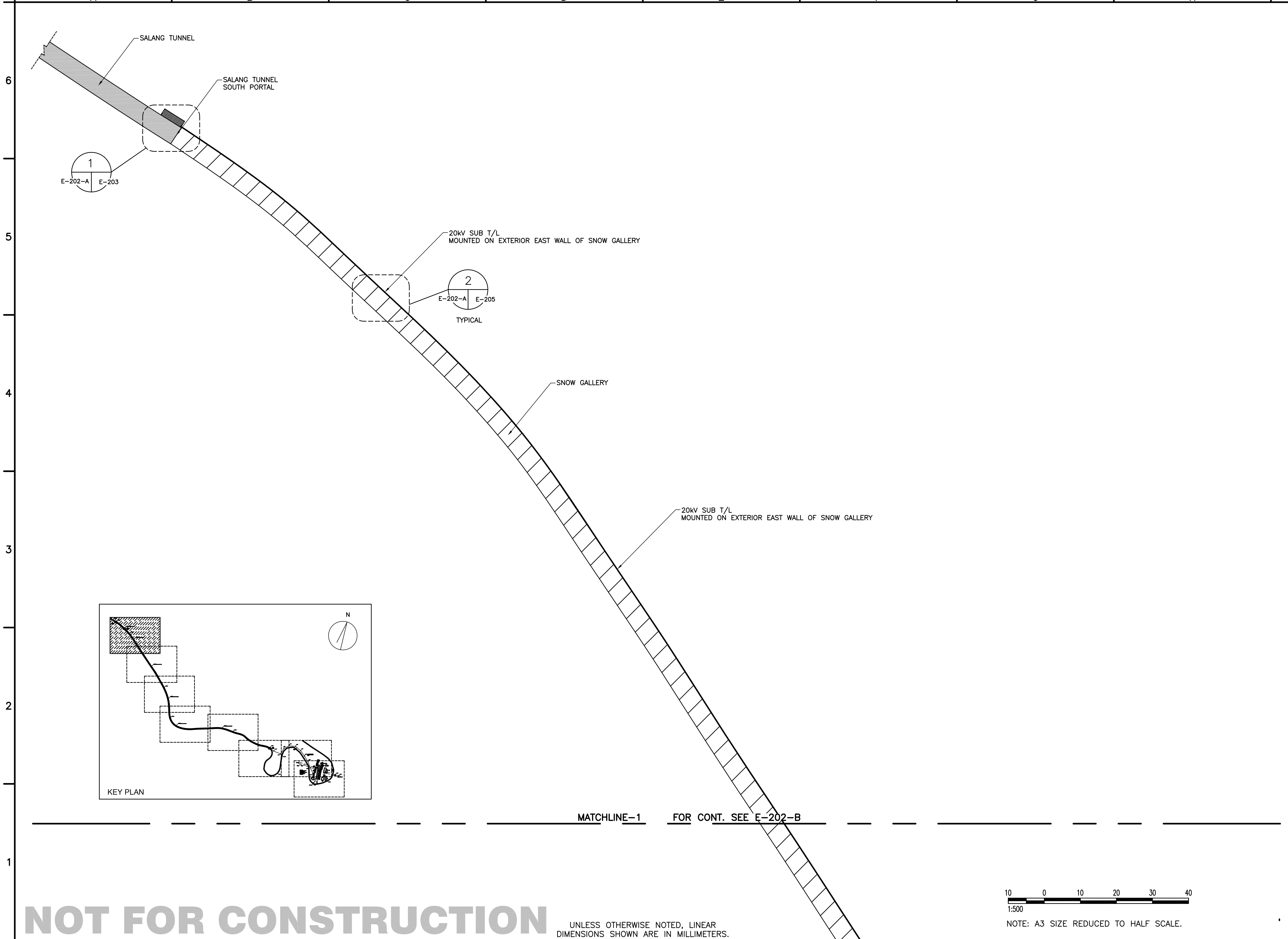
MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

USAID FROM THE AMERICAN PEOPLE

AESP

DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	



NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

NOTE: A3 SIZE REDUCED TO HALF SCALE.

DRAFT 12/3/2012 9:09 AM

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SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

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DESIGNED BY: ML	DATE: 12/12/01
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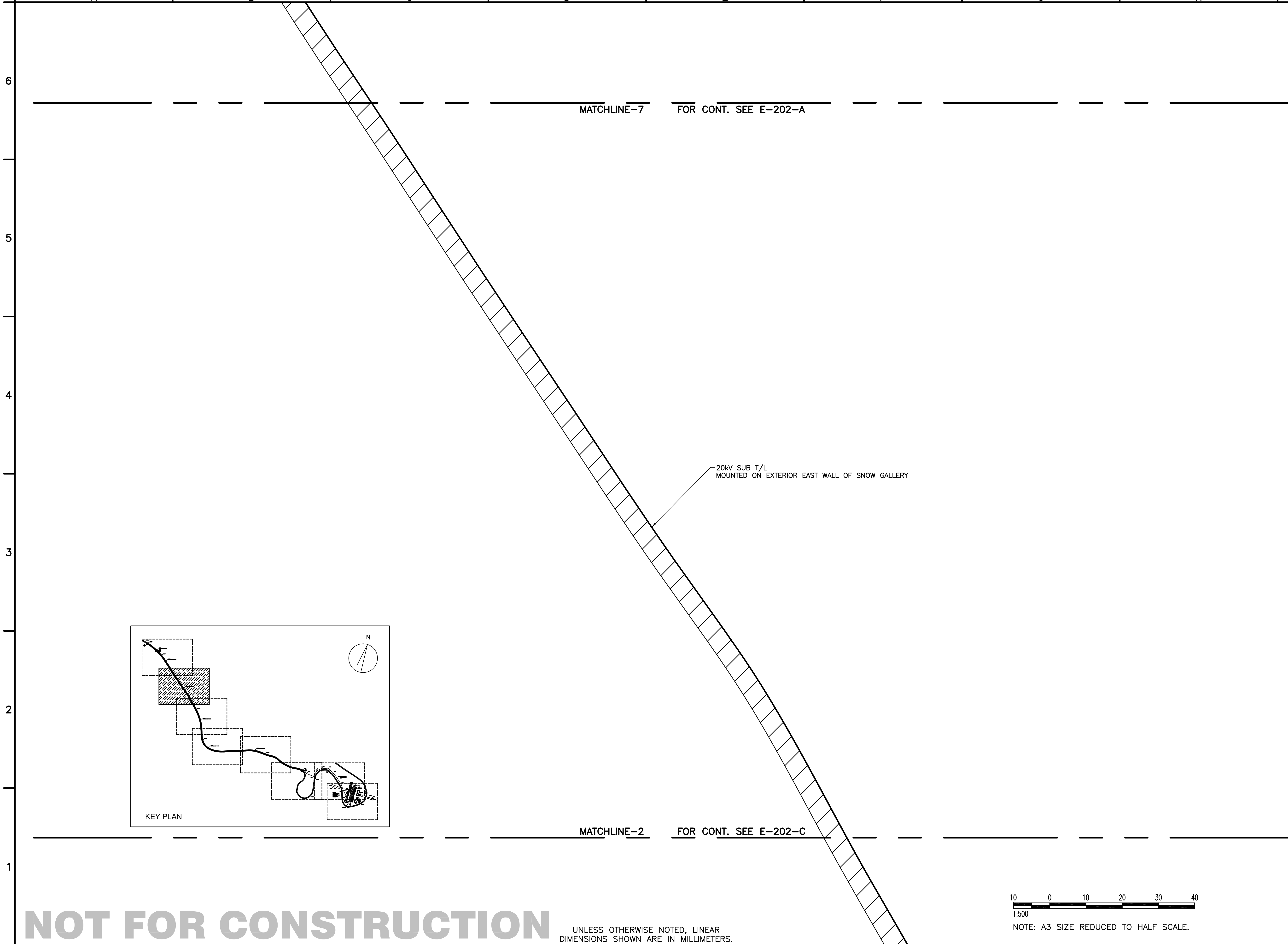
CHK BY:	FILE NO.: E-202

SHEET REFERENCE NUMBER: E-202-A

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E202.dwg 12/3/2012 9:09:02 AM Wahidi, Tarik



NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

10 0 10 20 30 40
1:500
NOTE: A3 SIZE REDUCED TO HALF SCALE.

DRAFT 12/3/2012 9:09 AM

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SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

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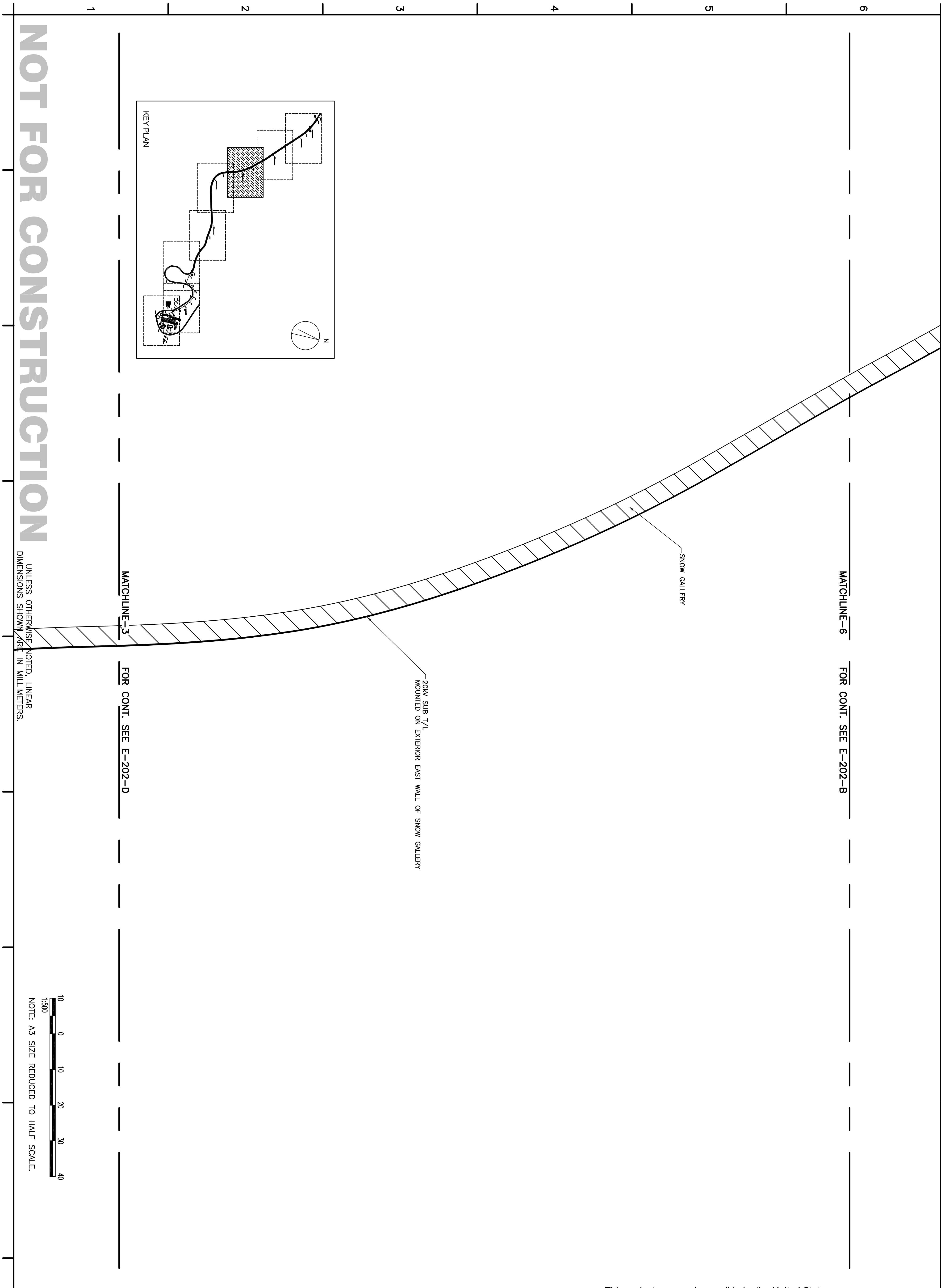
AESP

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

SHEET REFERENCE NUMBER: E-202-B



UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

1:500
10 0 10 20 30 40
NOTE: A3 SIZE REDUCED TO HALF SCALE.

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SHEET REFERENCE NUMBER: E-202-C

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

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AESP

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ML	12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

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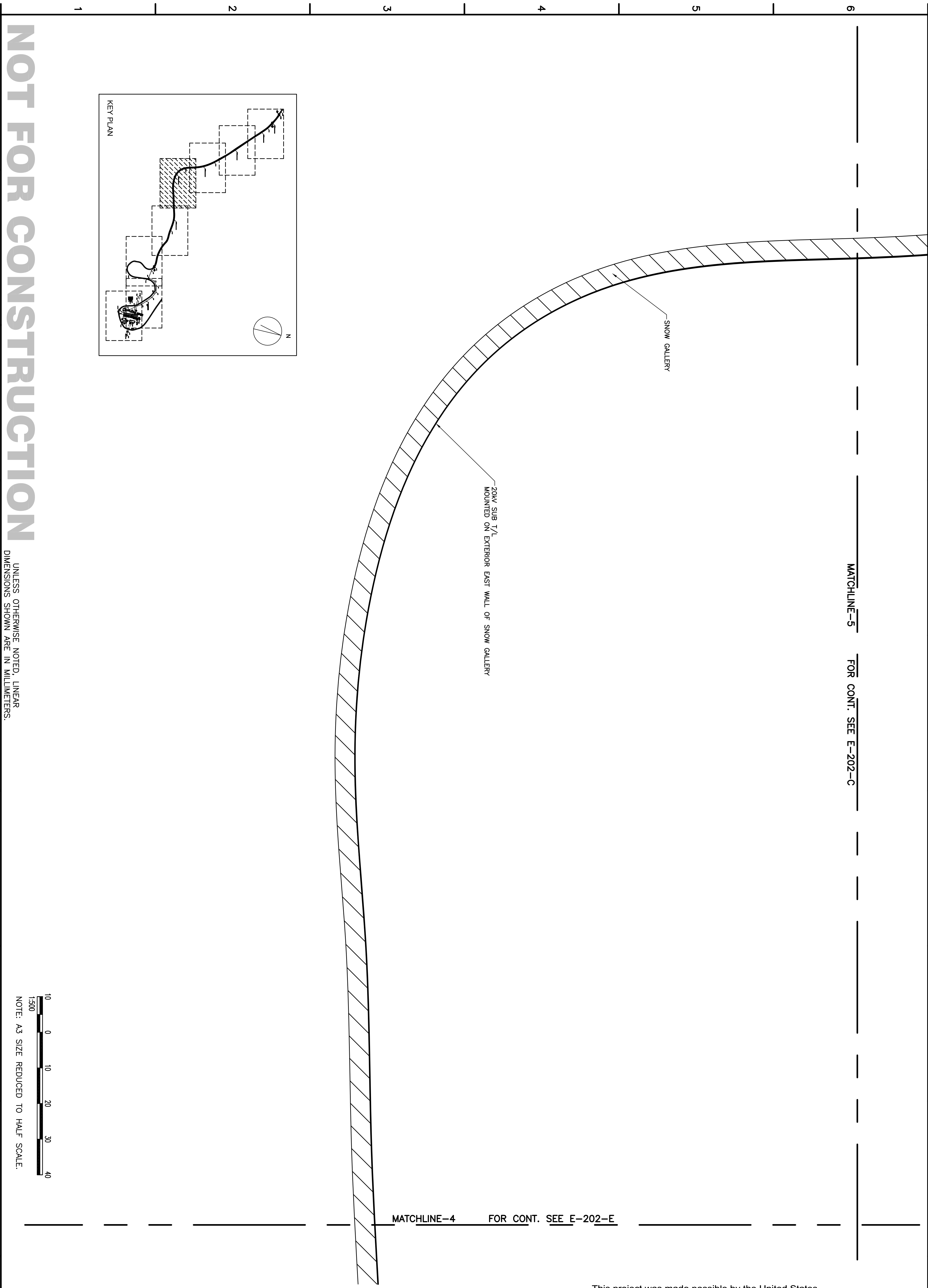
NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.



1:500
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NOTE: A3 SIZE REDUCED TO HALF SCALE.

DRAFT 12/3/2012 9:09 AM

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SHEET REFERENCE NUMBER: E-202-D

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

USAID FROM THE AMERICAN PEOPLE

AESP

DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

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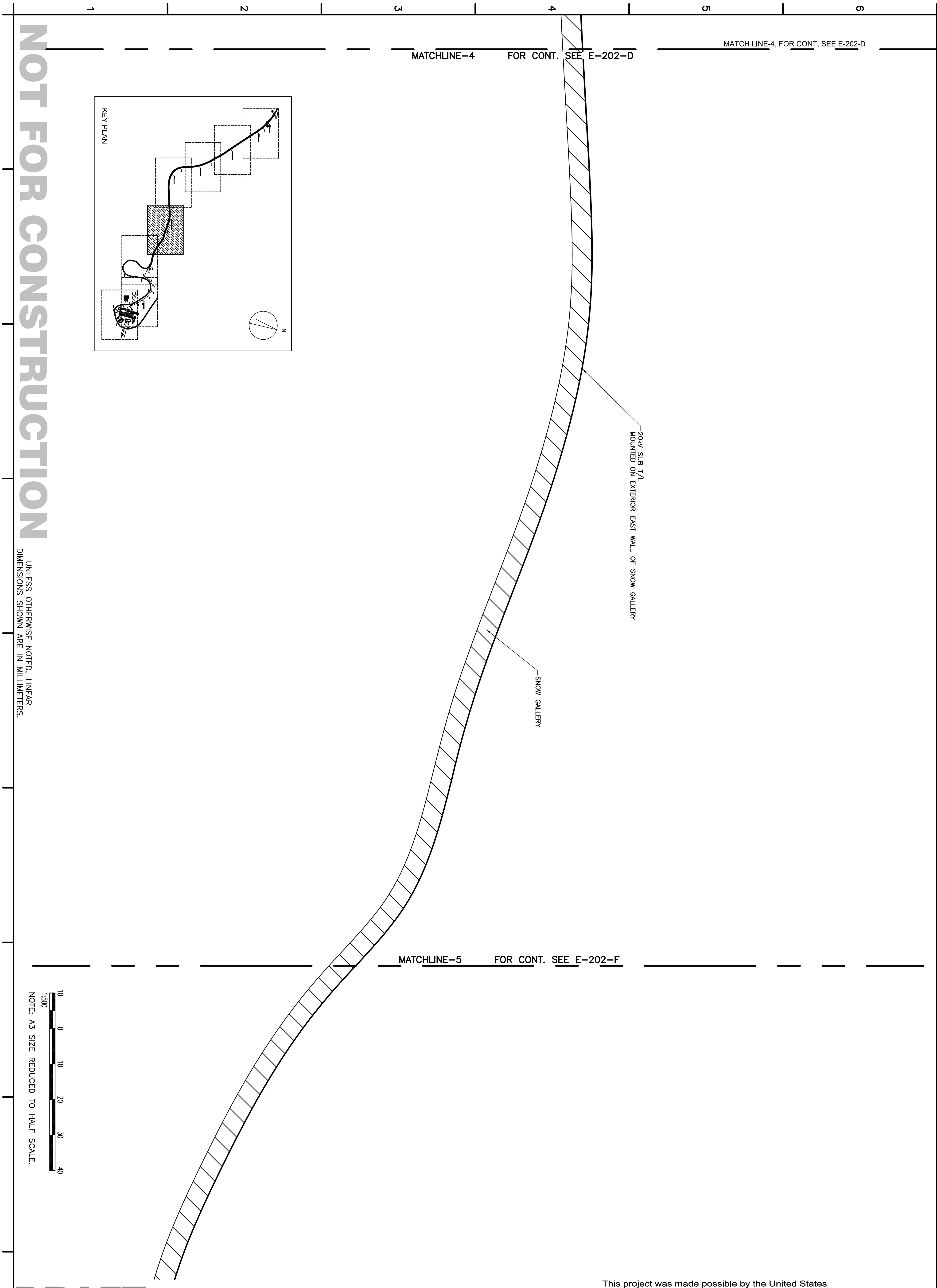

DRAFT 12/3/2012 9:10 AM

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SHEET REFERENCE NUMBER: E-202-E

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

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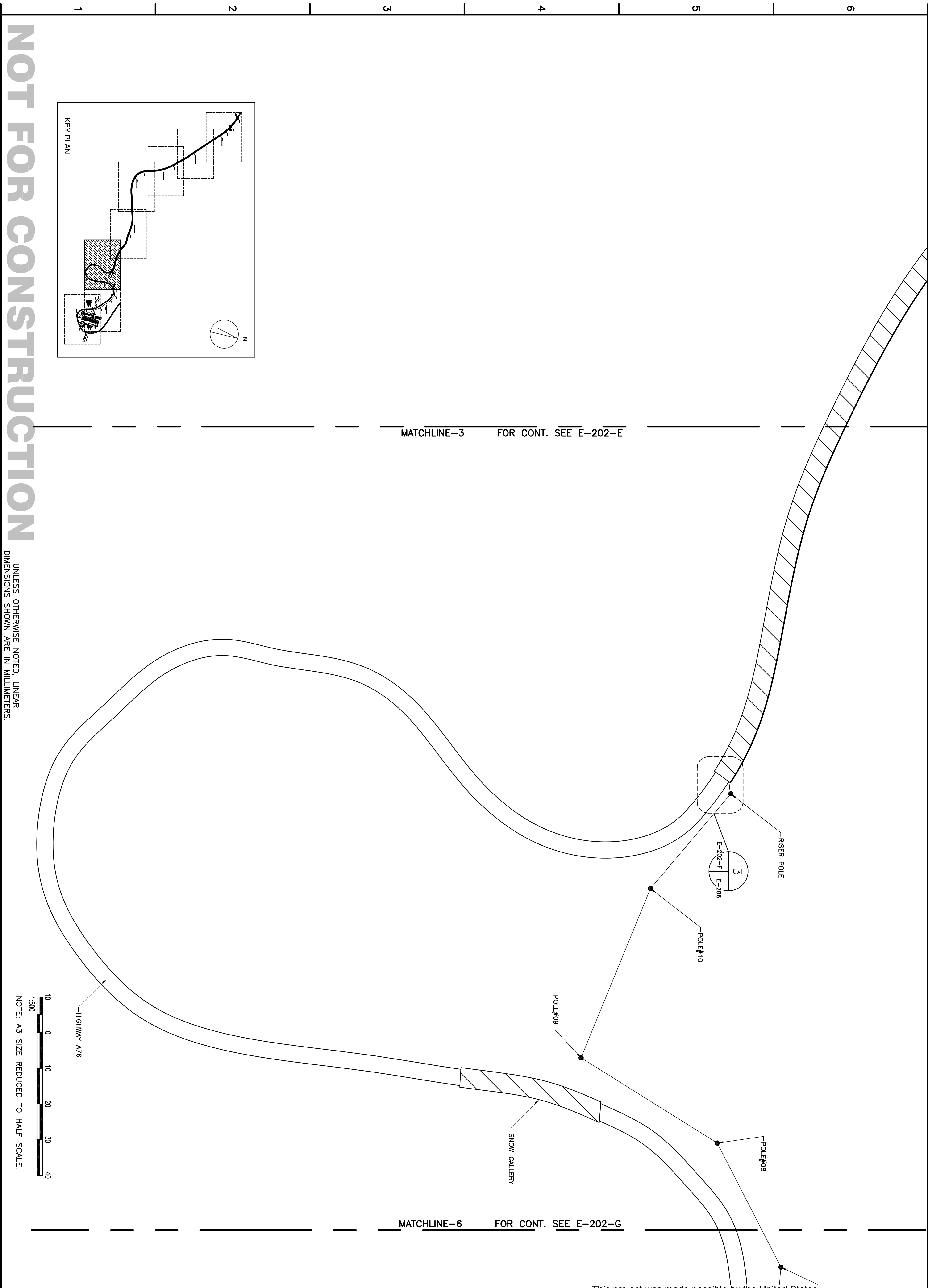
DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E202.dwg 12/3/2012 9:10:16 AM Wahidi, Tarik

NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.



1:500
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NOTE: A3 SIZE REDUCED TO HALF SCALE.

DRAFT 12/3/2012 9:10 AM

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SHEET REFERENCE NUMBER: E-202-F

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

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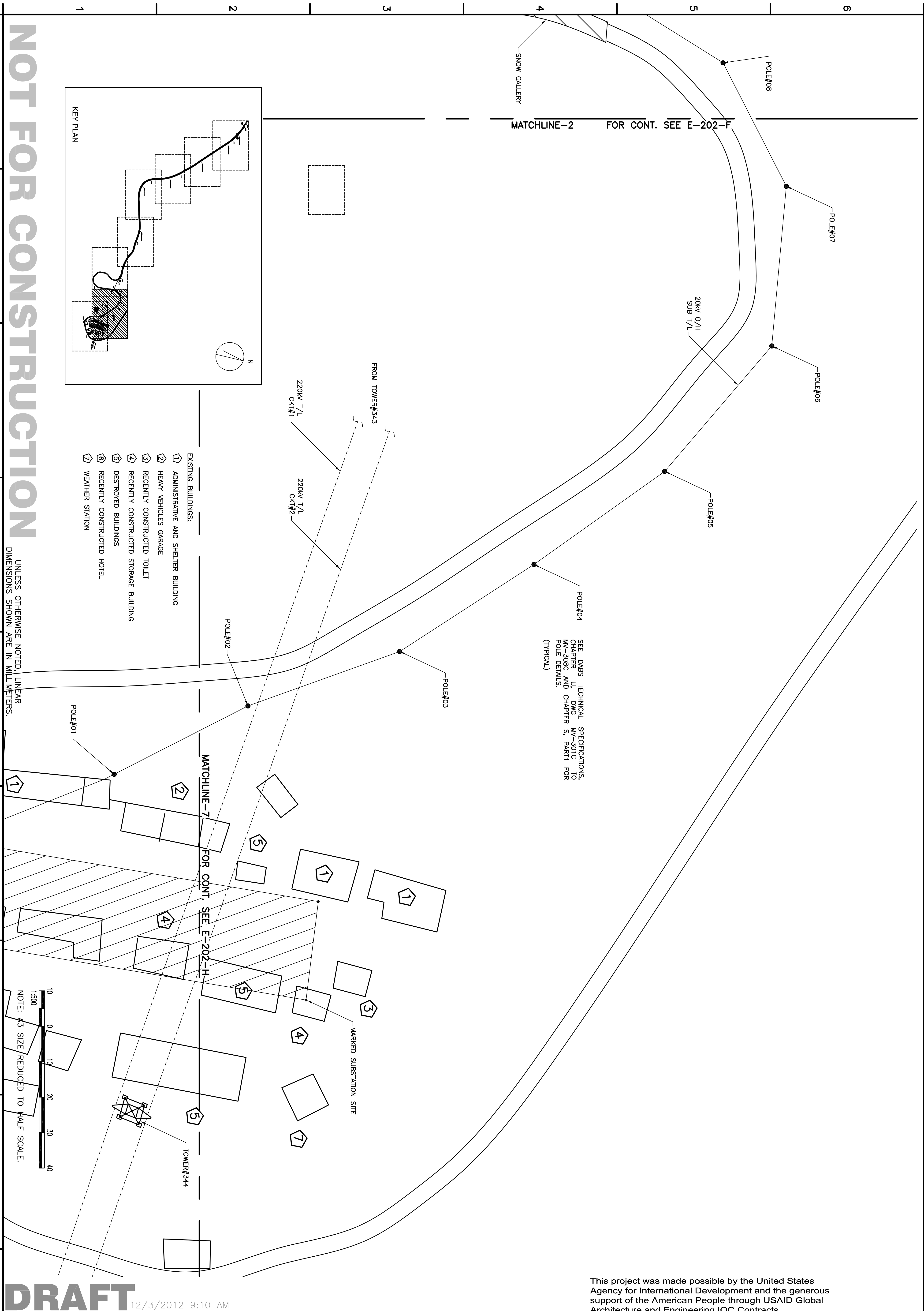
DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E202.dwg 12/3/2012 9:10:28 AM Wahidi, Tarik



This project was made possible by the United States Agency for International Development and the generous support of the American People through USAID Global Architecture and Engineering IQC Contracts.

SHEET REFERENCE NUMBER:		
E-202-G	SALANG TUNNEL SUBSTATION	MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

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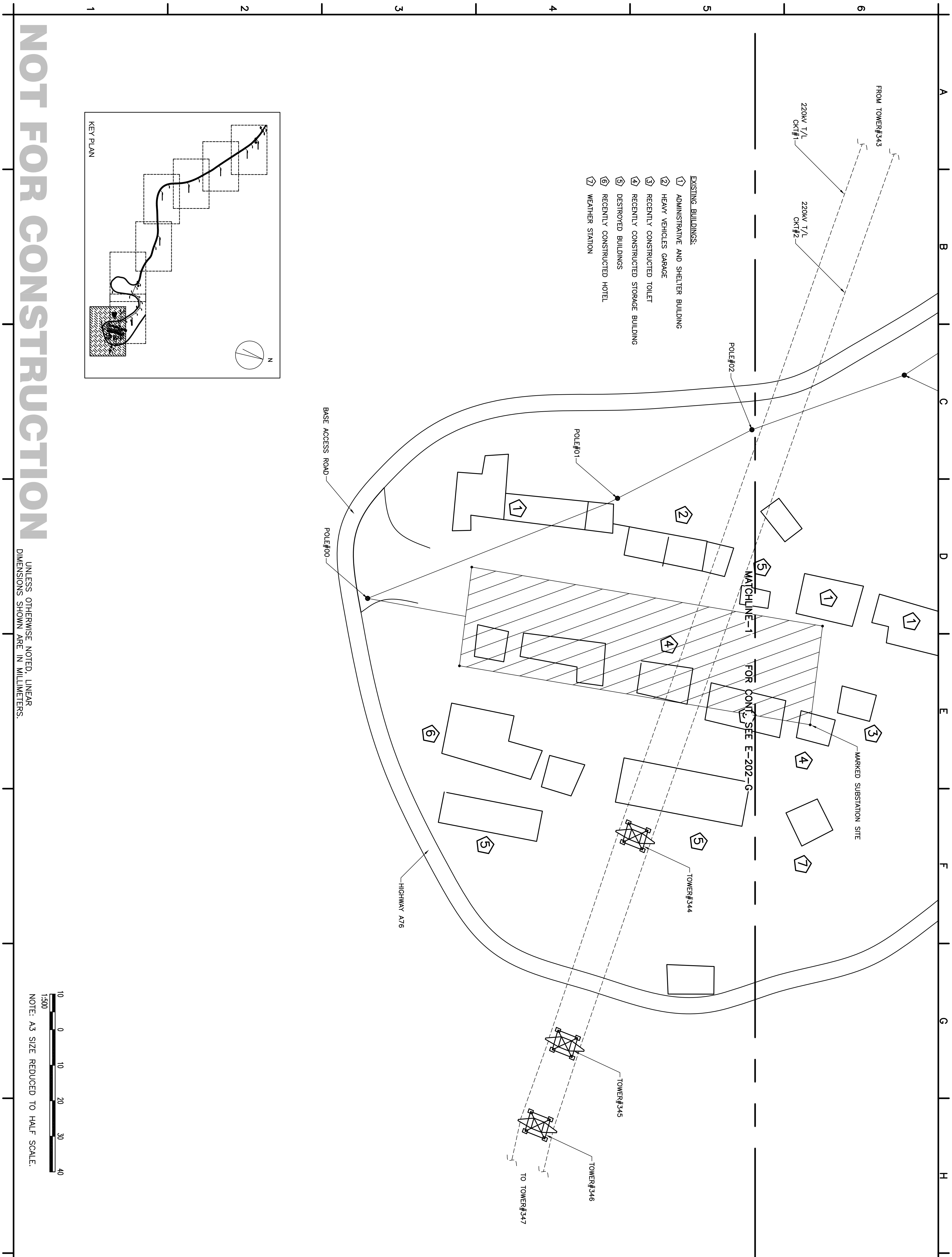
DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	



DRAFT 12/3/2012 9:10 AM

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SHEET REFERENCE NUMBER: E-202-H

SALANG TUNNEL SUBSTATION

MV WORK, 20kV SUB-TRANSMISSION LINE ROUTING PLAN CONTRACT-1C

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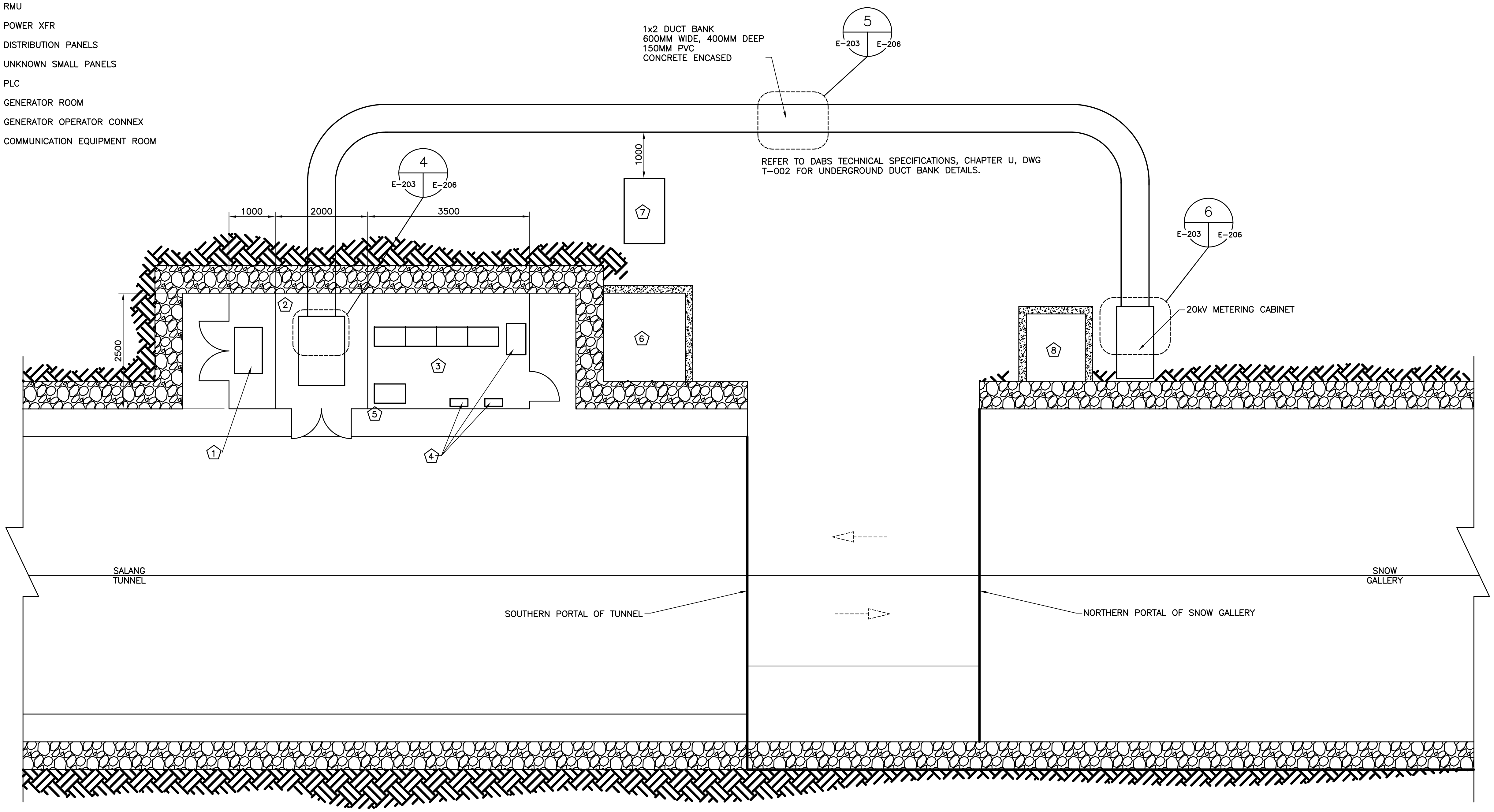
DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-202

SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/20	

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E203.dwg 12/3/2012 9:11:17 AM Wahidi, Tarik

EXISTING ITEMS:

1. RMU
2. POWER XFR
3. DISTRIBUTION PANELS
4. UNKNOWN SMALL PANELS
5. PLC
6. GENERATOR ROOM
7. GENERATOR OPERATOR CONNEX
8. COMMUNICATION EQUIPMENT ROOM



TUNNEL & GALLERY PLAN 1 E-202-A E-203
SCALE 1:50

1 0 1 2 3 4
1:50

NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

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SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/18	

DRAFT 12/3/2012 9:11 AM

SALANG TUNNEL SUBSTATION

MV WORK, MV SUBSTATION MODIFICATIONS PLAN- CONTRACT-1C

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AESP

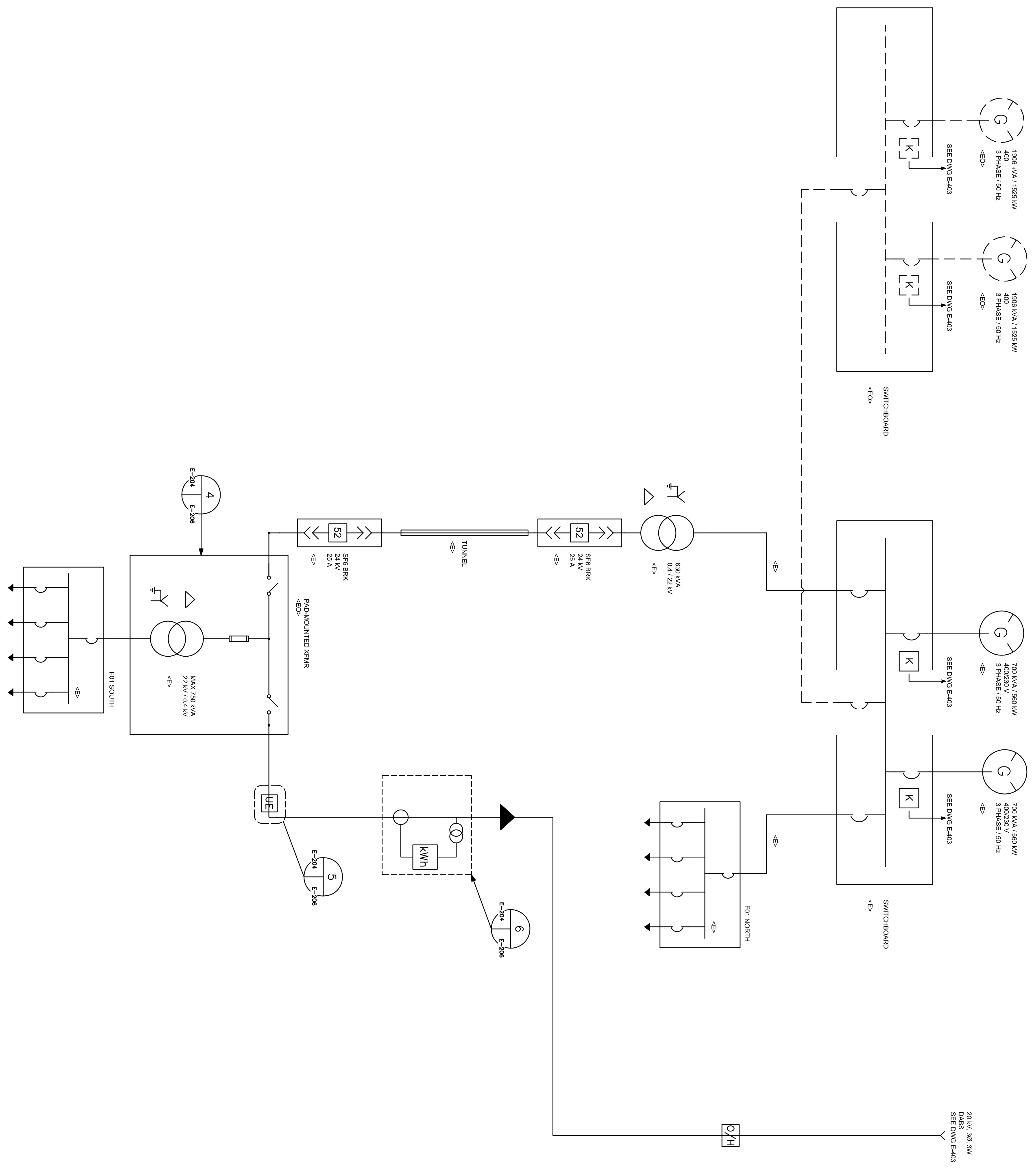
DESIGNED BY: ML	DATE: 12/12/01
DWN BY: MAY	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-203

SHEET REFERENCE NUMBER: E-203

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E204.dwg 12/3/2012 9:11:41 AM Wahidi, Tarik

NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.



DRAFT 12/3/2012 9:11 AM

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SHEET REFERENCE NUMBER: E-204

SALANG TUNNEL SUBSTATION

MV WORK, MV S/S MODIFICATIONS
ONE-LINE DIAGRAM-CONTRACT-1C

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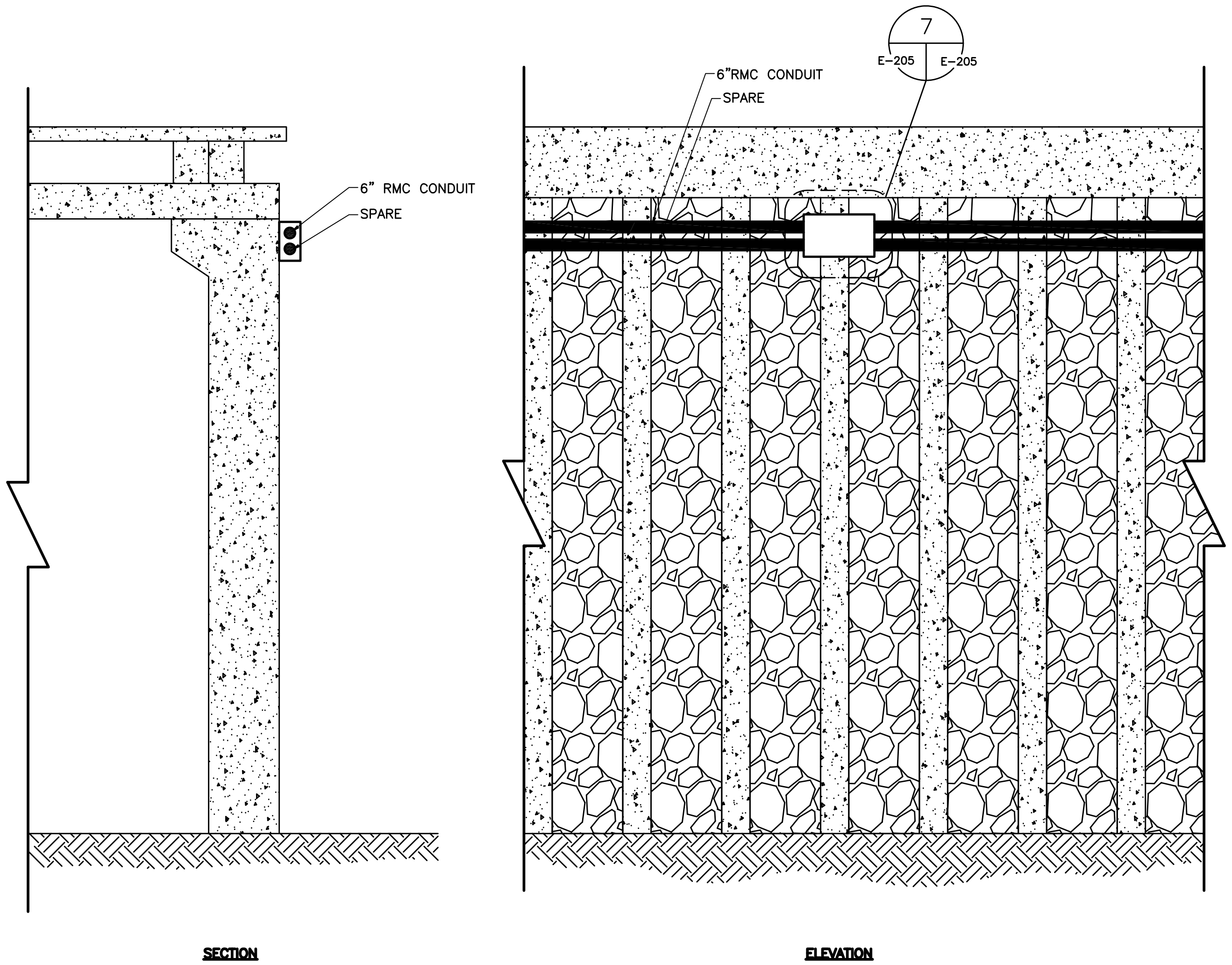
AESP

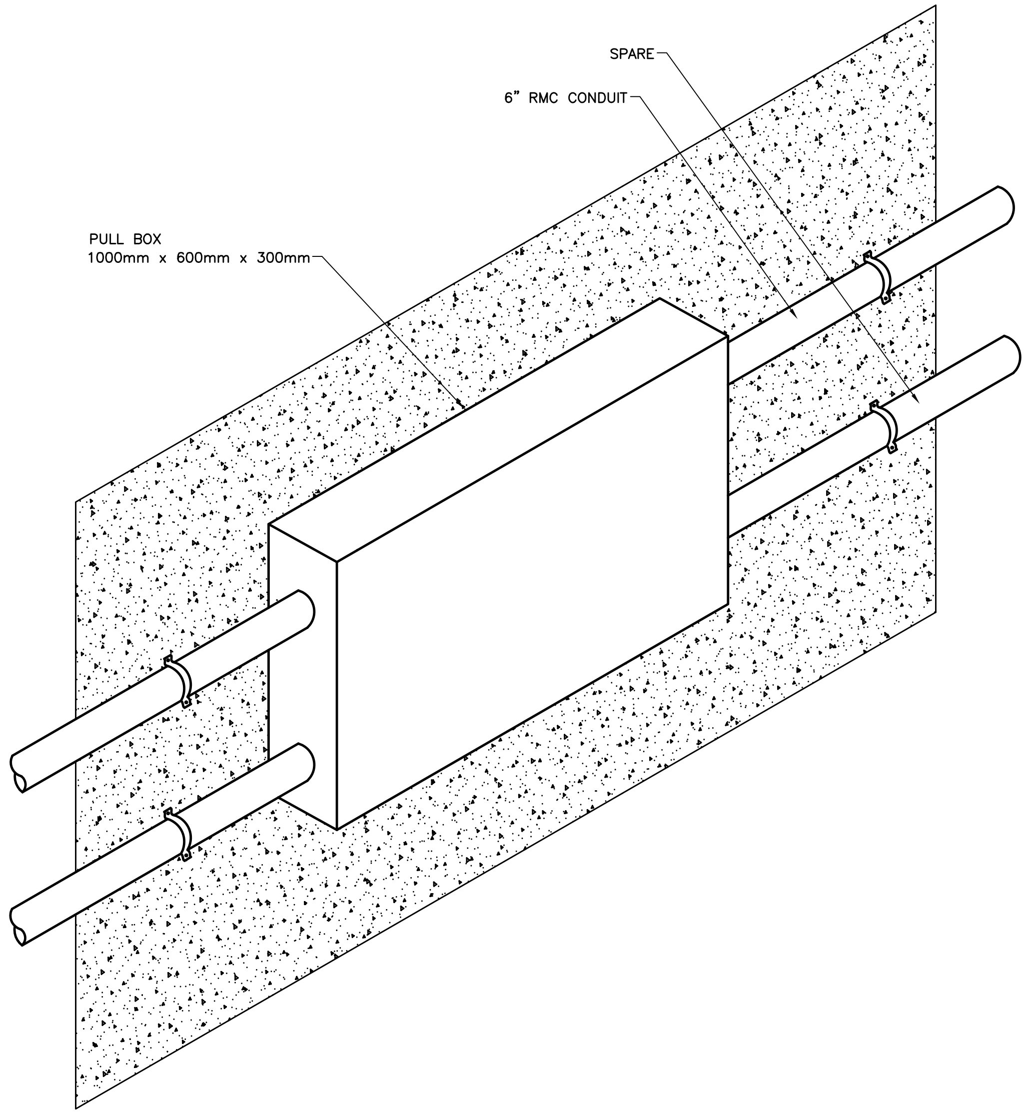
DESIGNED BY: ML	DATE: 12/12/01
DWN BY: TW	SUBMITTED BY: TETRA TECH
CHK BY:	FILE NO.: E-204

SYMB	DESCRIPTION	DATE	APR
A	CONCEPT	12/11/15	

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E205.dwg 12/3/2012 9:12:08 AM Wahidi, Tarik



PULL BOX AND RACEWAY DETAILS 2
SCALE 1:50 E-202-A E-205



PULL BOX DETAILS 7
NTS E-205 E-205

NOT FOR CONSTRUCTION

UNLESS OTHERWISE NOTED, LINEAR DIMENSIONS SHOWN ARE IN MILLIMETERS.

1:50 — 1 0 1 2 3 4

NOTE: A3 SIZE REDUCED TO HALF SCALE.

DRAFT 12/3/2012 9:12 AM

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SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/05	

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CHK BY:	FILE NO.: E-205

SALANG TUNNEL SUBSTATION

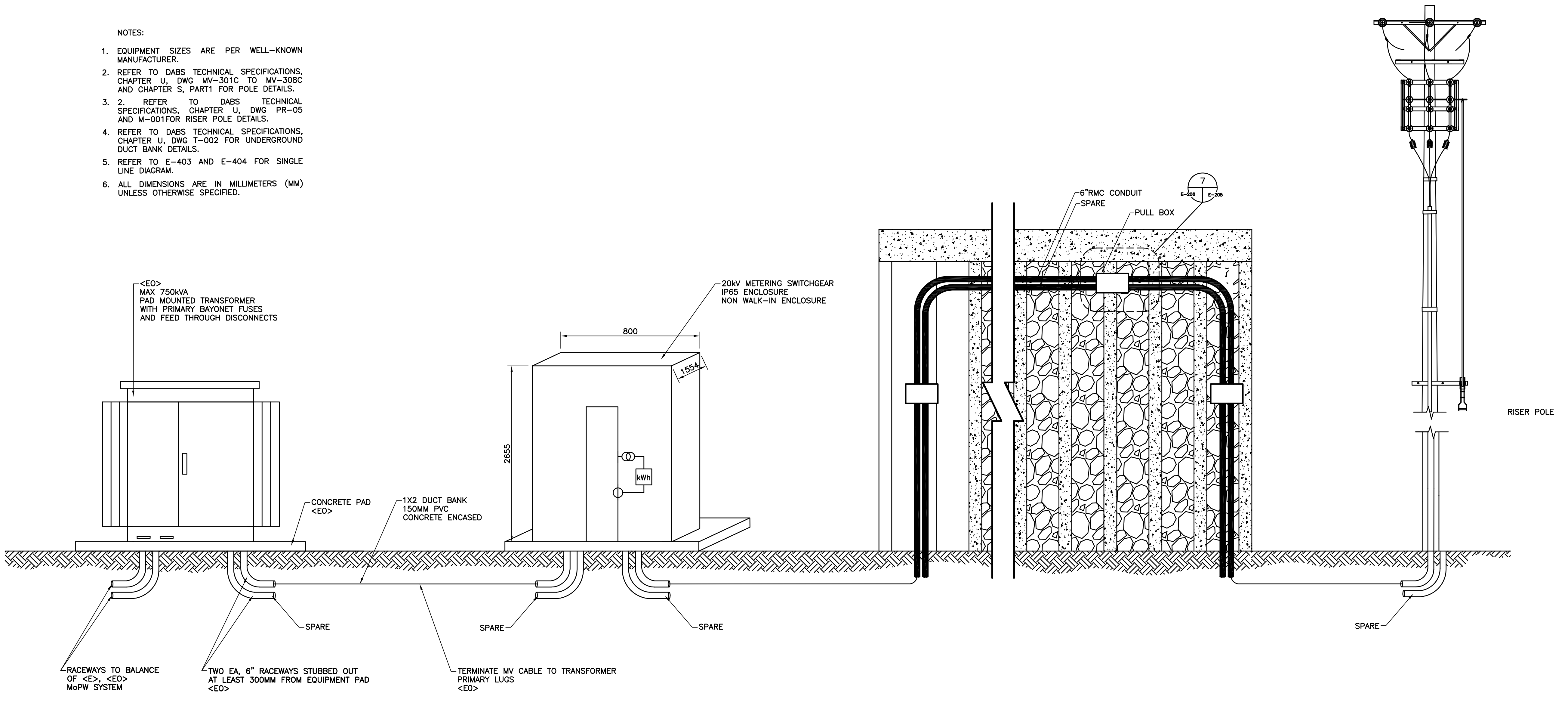
MV WORK, 20kV SUB-TRANSMISSION LINE DETAILS-CONTRACT-1C

SHEET REFERENCE NUMBER: E-205

P:\1298\Work Orders\WO-LT\WO-LT-0063 Salang Tunnel SS Technical Sections\CAD\Conceptual\121030 WOLT0063-E206.dwg 12/3/2012 9:12:34 AM Wahidi, Tarik

NOTES:

1. EQUIPMENT SIZES ARE PER WELL-KNOWN MANUFACTURER.
2. REFER TO DABS TECHNICAL SPECIFICATIONS, CHAPTER U, DWG MV-301C TO MV-308C AND CHAPTER S, PART1 FOR POLE DETAILS.
3. 2. REFER TO DABS TECHNICAL SPECIFICATIONS, CHAPTER U, DWG PR-05 AND M-001FOR RISER POLE DETAILS.
4. REFER TO DABS TECHNICAL SPECIFICATIONS, CHAPTER U, DWG T-002 FOR UNDERGROUND DUCT BANK DETAILS.
5. REFER TO E-403 AND E-404 FOR SINGLE LINE DIAGRAM.
6. ALL DIMENSIONS ARE IN MILLIMETERS (MM) UNLESS OTHERWISE SPECIFIED.



U/G RACEWAY DETAILS 4
NTS
E-203 E-204 E-206

U/G RACEWAY DETAILS 5
NTS
E-203 E-204 E-206

SWITCHGEAR/METERING CABINET DETAILS 6
NTS
E-203 E-204 E-206

RISER POLE AND TRANSITION TO MV IN RACEWAY DETAILS 3
N.T.S
E-202-F E-206

NOT FOR CONSTRUCTION

NTS

DRAFT 12/3/2012 9:12 AM

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SYMB	DESCRIPTION	DATE	APR
	CONCEPT	12/11/05	

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AESP

DESIGNED BY: ML
DATE: 12/12/01
DWN BY: TW
SUBMITTED BY: TETRA TECH
CHK BY:
FILE NO.: E-206

SALANG TUNNEL SUBSTATION

MV WORK, SWITCHGEAR DETAILS
CONTRACT-1C

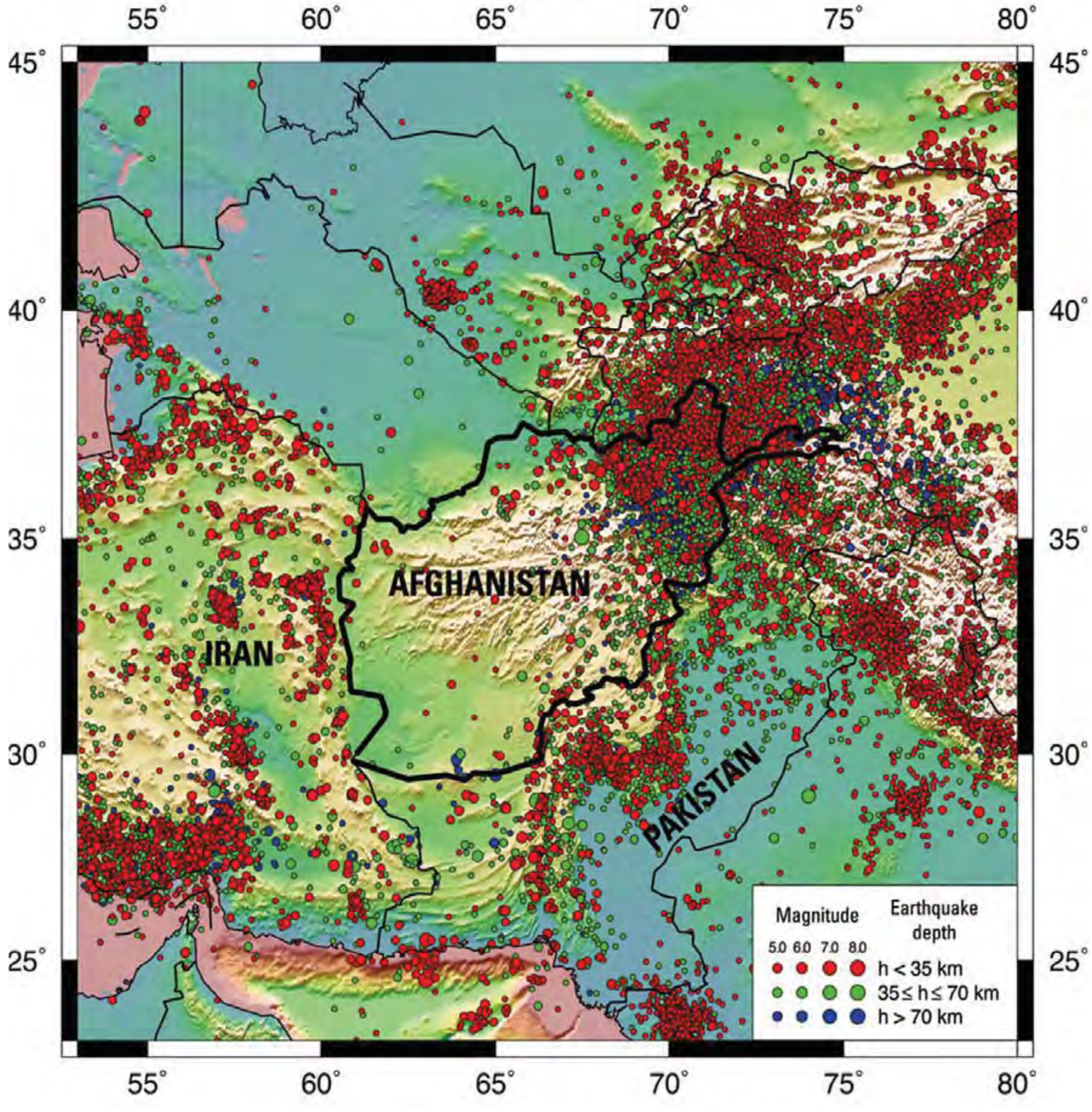
SHEET REFERENCE NUMBER:

E-206

Section D

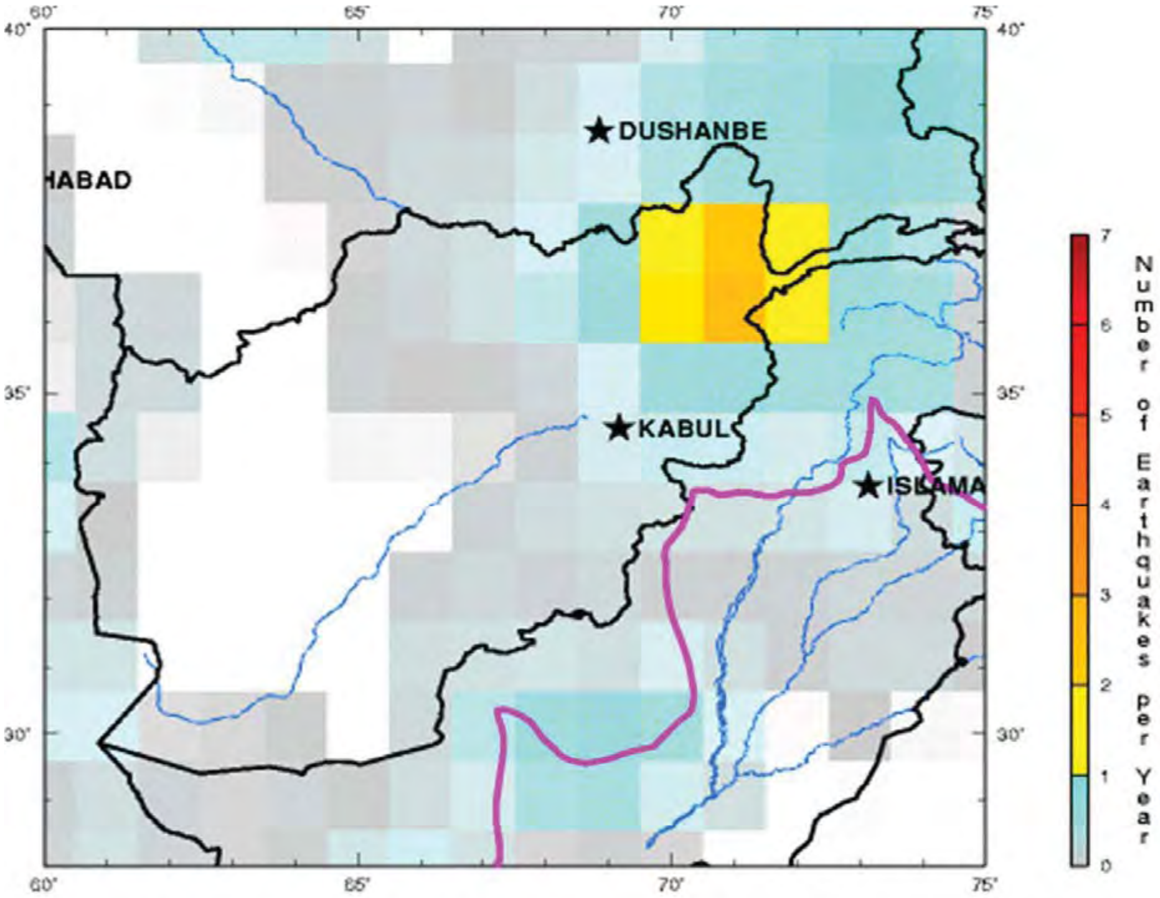
Informative Earthquake Map

Seismicity of the Afghanistan Region



MAP ESDIP TL 04 01

EARTHQUAKE DENSITY MAP

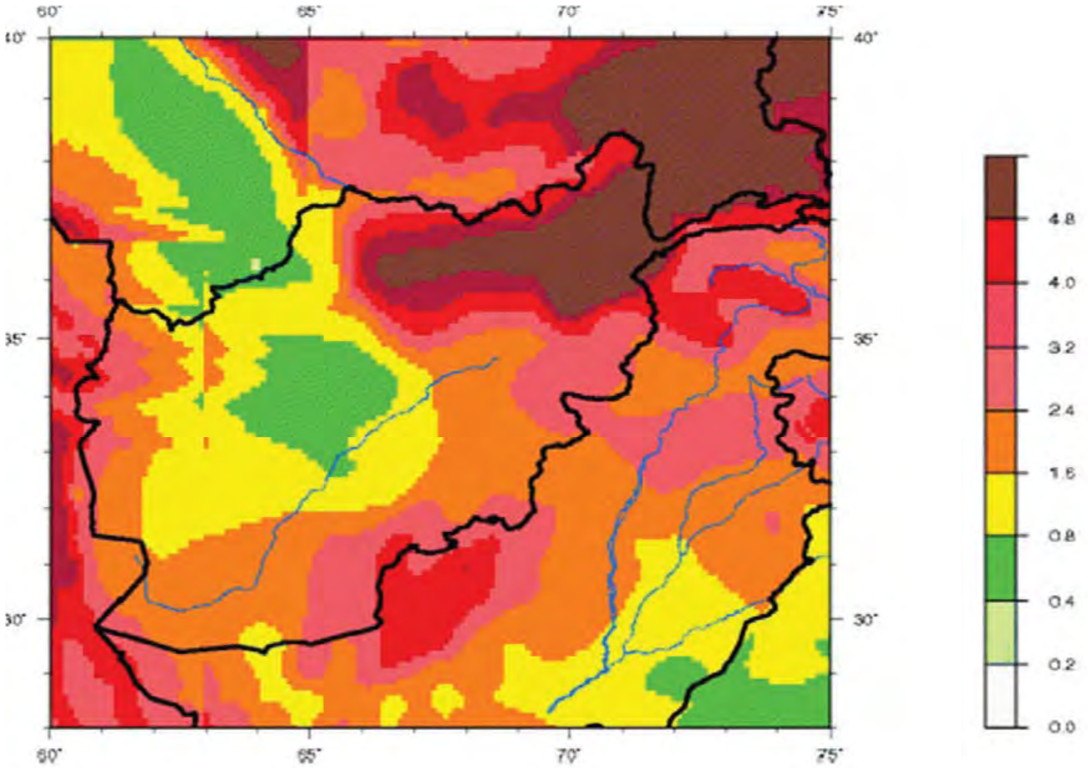


Number of Earthquakes per Year, Magnitude 5 and Greater, All Depths

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green

MAP ESDIP TL 04 02

SEISMIC HAZARD MAP



Peak Ground Acceleration (m/s²) with 10% Probability of Exceedance in 50 Years

MAP ESDIP TL 04 03

Appendix A

Medium and Low Voltage Distribution Network Standard Technical Specifications
Chapter U, Distribution Standards

CHAPTER U

DISTRIBUTION STANDARDS

DISTRIBUTION CONSTRUCTION MATERIALS

ASSEMBLIES

MV STRUCTURES

LV STRUCTURES

TRENCHES

FIBER OPTIC CABLES

SWITCHING EQUIPMENT

MISCELLANEOUS

GUY

CABLES AND CONDUCTORS

MV UNDERGROUND CABLES/ACCESSORIES

LV UNDERGROUND CABLES/ACCESSORIES

OVERHEAD MV CONDUCTOR/ACCESSORIES

ABC LV CABLES AND ACCESSORIES

INSULATOR AND ACCESSORIES

MISCELLANEOUS

GUY

MV UNDERGROUND CABLES/ACCESSORIES

LV UNDERGROUND CABLES/ACCESSORIES

OVERHEAD MV CONDUCTOR/ACCESSORIES

ABC LV CABLES AND ACCESSORIES

INSULATOR AND ACCESSORIES

GUY

MINISTRY OF ENERGY AND WATER decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH Rehabilitation and extension of the Kabul City distribution Network	DISTRIBUTION CONSTRUCTION MATERIALS	
	INDEX	
	DATE 01/2005	PAGE NO. 1/17

MISCELLANEOUS

C1

MV UNDERGROUND CABLE 12/20 KV, N2XS2Y, single core, copper, XLPE according to Chapter C (Tech. Specification)

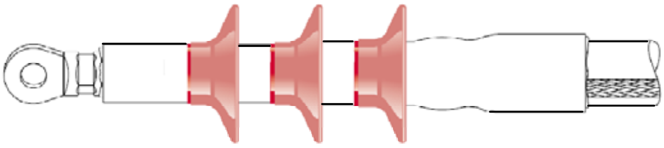
	Size	Insulated
a)	1 x 50 RM / 16	12/20 kV
b)	1 x 95 RM / 16	12/20 kV
c)	1 x 120 RM / 16	12/20 kV
d)	1 x 240 RM / 25	12/20 kV

Used for interconnections electrical station and outgoings to overhead line

T1

OUTDOOR TERMINATION KIT 20 KV, XLPE insulation according to Chapter C (Technical Specification)

	For cable size
a)	1 x 50 RM / 16
b)	1 x 95 RM / 16
c)	1 x 120 RM / 16
d)	1 x 240 RM / 25



Used for outdoor MV underground termination cable

T2

INDOOR TERMINATION KIT 20 KV, XLPE insulation according to Chapter C (Technical Specification)

	For cable size
a)	1 x 50 RM / 16
b)	1 x 95 RM / 16
c)	1 x 120 RM / 16
d)	1 x 240 RM / 25

Used for indoor MV underground termination cable

Comment

J1

STRAIGHT JOINTS KIT 20 KV, XLPE insulation according to Chapter C (Technical Specification)

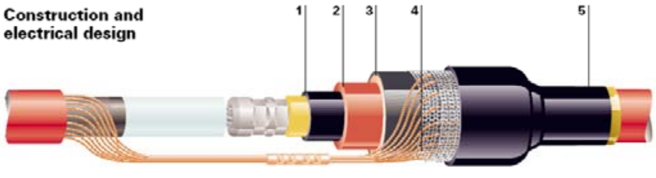
For cable size

a) 1 x 50 RM / 16

b) 1 x 95 RM / 16

c) 1 x 120 RM / 16

d) 1 x 240 RM / 25



Used for joint MV underground cable

C2

SHRINK CAP, XLPE insulation according to Chapter C (Technical Specification)

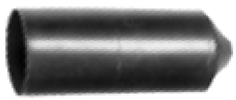
For cable size

a) 1 x 50 RM / 16

b) 1 x 95 RM / 16

c) 1 x 120 RM / 16

d) 1 x 240 RM / 25



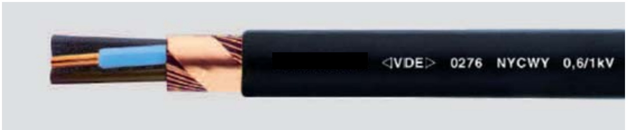
Used for protection underground cable

Comment

C3

LV UNDERGROUND CABLE 0.6/1 KV, NYCWY, concentric copper conductor according to Chapter D (Tech. Specification)

	Size	Insulated
a)	4 x 50 SM / 25	0.6/1 kV
b)	4 x 120 SM / 70	0.6/1 kV
c)	4 x 150 SM / 70	0.6/1 kV



Used for interconnections between compact station to overhead line, feeder pillar and meter boxes

C4

LV UNDERGROUND CABLE 0.6/1 KV, NYY-J,three core according to Chapter D (Technical Specification)

	Size	Insulated
a)	3 x 4 RE	0.6/1 kV
b)	3 x 6 RE	0.6/1 kV
c)	3 x 10 RE	0.6/1 kV
d)	3 x 16 RE	0.6/1 kV
e)	5 x 10 RE	0.6/1 kV
f)	5 x 16 RE	0.6/1 kV
g)	5 x 25 RM	0.6/1 kV
h)	1 x 240 RM	0.6/1 kV
i)	1 x 120 RM	0.6/1 kV

Item a) to g) used for interconnections between service cable to meter boxers and customer

Item h) used for connections LV neutral transformer

Item i) used for interconnections between LV transformer to feeder pillar

Comment

T3

OUTDOOR TERMINATION KIT 0.6/1 KV, according to Chapter D (Technical Specification)

For cable size

a) NYCWY 4 x 50 SM/25
b) NYCWY 4 x 120 SM/70
c) NYCWY 4 x 150 SM/70

J2

UNDERGROUND STRAIGHT JOINT KIT 0.6/1 KV, according to Chapter D (Technical Specification)

For cable size

a) NYCWY 4 x 50 SM/25
b) NYCWY 4 x 120 SM/70
c) NYCWY 4 x 150 SM/70

C5

END CAP 0.6/1 KV, according to Chapter D (Technical Specification)

For cable size

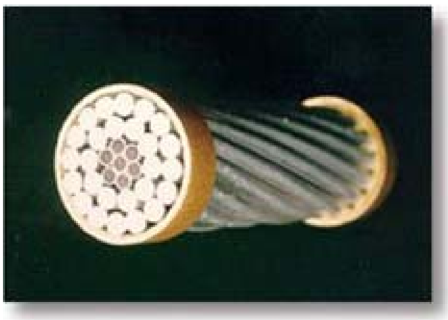
a) NYCWY 4 x 50 SM/25
b) NYCWY 4 x 120 SM/70
c) NYCWY 4 x 150 SM/70

Comment

C6

ALUMINUM ALLOY CONDUCTOR STEEL REINFORCED (ACSR), according to Chapter E (Technical Specification)

	Code	Overall diameter	Weight	Breaking load
a)	70/12	11.5 mm	284 kg/km	26800 N
b)	120/20	15.5 mm	493 kg/km	45650 N
c)	185/30	19.0 mm	741 kg/km	66200 N



Used for transport energy in Medium Voltage

S1

COMPRESSION SPLICE, full tension for ACSR conductor according to Chapter E (Technical Specification)

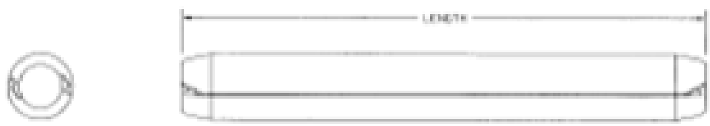
	Conductor size	Overall diameter
a)	70/12 mm²	11.5 mm
b)	120/20 mm²	15.5 mm
c)	185/30 mm²	19.0 mm

Used for joint conductor ACSR

S2

REPAIR SLEEVE, for ACSR conductor according to Chapter E (Technical Specification)

	Conductor size	Overall diameter
a)	70/12 mm²	11.5 mm
b)	120/20 mm²	15.5 mm
c)	185/30 mm²	19.0 mm



Used for repair conductor ACSR

Comment

C7

COMPRESSION TAP CONNECTOR, Type H according to Chapter E (Technical Specification)

	Main conductor (diameter)	Tap conductor (diameter)
a)	70/12 mm² (11.5 mm)	70/12 mm² (11.5 mm)
b)	120/20 mm² (15.5 mm)	120/20 mm² (15.5 mm)
c)	185/30 mm² (19.0 mm)	185/30 mm² (19.0 mm)
d)	120/20 mm² (15.5 mm)	70/12 mm² (11.5 mm)
e)	185/30 mm² (19.0 mm)	70/12 mm² (11.5 mm)
f)	185/30 mm² (19.0 mm)	120/20 mm² (15.5 mm)

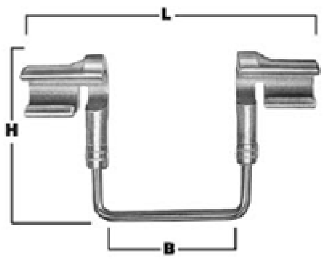
Used for joint conductor ACSR

S3

COMPRESSION STIRRUP CONNECTOR , for ACSR conductor, casting aluminum alloy and stirrup copper rod according to Chapter E (Technical Specification)

	Casting for conductor		Stirrups section
	Size	Diameter	
a)	70/12 mm²	11.5 mm	10 mm
b)	120/20 mm²	15.5 mm	10 mm
c)	185/30 mm²	19.0 mm	10 mm

H min = 95 mm and Bmin = 100 mm



Used for protect conductor of electric arcing

C8

HOT LINE CLAMP, for installation on compression stirrups according to Chapter E (Technical Specification)

	Main	Tap
a)	4 - 10 mm	4 - 10 mm

Used for installation on energized conductor

Comment

C9

ABC CABLES (QUADRUPLEX) 0.6/1 KV, aluminum conductor according to Chapter F (Technical Specification)

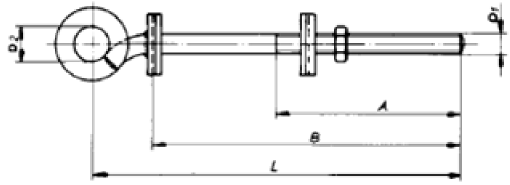
	Phases conductor	Neutral messenger
a)	3 x 50 mm²	1 x 50 mm²
b)	3 x 95 mm²	1 x 70 mm²
c)	3 x 120 mm²	1 x 70 mm²

Used for transport energy in low voltage overhead line

S4

SPIRAL (PIG TAIL) HOOK, with square washer, spring washer and nut according to Chapter F (Technical Specification)

	Dimensions	
	Diameter	Length
a)	M16	300 mm
b)	M16	360 mm



Spiral Hook

Used for support low voltage cables

N1

NUT HOOK, according to Chapter F (Technical Specification)

	For bolt
a)	M 16

Used for support low voltage cables

N2

NUT HOOK (EXTERNAL ANGLE), for non-insulated neutral AAAC according to Chapter F (Technical Specification)

For bolt M16

Used for support neutral messenger in low voltage overhead line

Comment

C10

DEAD END CLAMP, for non-insulated neutral AAAC with cutting according to Chapter F (Technical Specification)

Neutral section

a) 50 mm²

b) 70 mm²

Used for support neutral messenger in low voltage overhead line

C11

DEAD END CLAMP, for non-insulated neutral AAAC without cutting according to Chapter F (Technical Specification)

Neutral section

a) 50 mm²

b) 70 mm²

Used for support neutral messenger in low voltage overhead line

C12

SUSPENSION CLAMP (UP TO 30º), for non-insulated neutral AAAC according to Chapter F (Technical Specification)

Neutral section

a) 50 mm²

b) 70 mm²

Used for support neutral messenger in low voltage overhead line

Y1

YOKE UNIVERSAL, with two suspension clamps (line angles up to 60º) according to Chapter F (Technical Specification)

Neutral section

a) 50 – 70 mm²

Used for support neutral messenger in low voltage overhead line

Comment

S5

PRE-INSULATED SLEEVES, for Aluminum conductor according to Chapter F (Technical Specification)

Conductor section

a) 50 mm²

b) 95 mm²

c) 120 mm²

Used for joint conductor LV

S6

COMPRESSION SLEEVES (FULL TENSION), for non-insulated neutral according to Chapter F (Technical Specification)

Neutral section

a) 50 mm²

b) 70 mm²

Used for joint neutral messenger

C13

INSULATION PIERCING CONNECTOR, for insulated overhead lines according to Chapter F (Technical Specification)

	Main range	Branch range
a)	25-95 mm² AL	25-95 mm² AL
b)	50-120 mm² AL	50-120 mm² AL
c)	25-95 mm² AL	4-70 mm² CU
d)	50-120 mm² AL	10-95 mm² CU

Used for branch conductor

Comment

C14

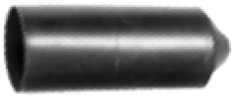
SEALING CAP 0.6/1 KV, according to Chapter F (Technical Specification)

Conductor section

a) 50 mm²

b) 95 mm²

c) 120 mm²



Used for protection cables LV

Comment

I1

SUSPENSION INSULATOR, porcelain, ball and socket according to Chapter Q (Technical Specification)

	Disc diameter	Spacing	Mechanical failing load
a)	175 mm	110 mm	40 kN

Used for support conductor Medium Voltage

I2

PIN TYPE INSULATOR, porcelain according to Chapter Q (Technical Specification)

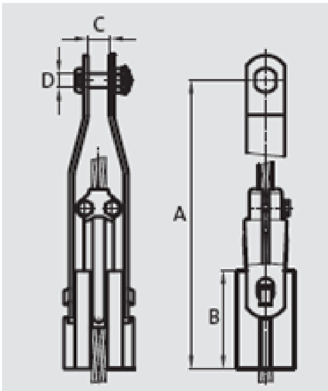
	Dimensions Diameter	Height	Mechanical cantilever load
a)	238 mm	158 mm	20 kN

Used for support conductor Medium Voltage

C15

WEDGE TYPE TENSION CLAMP, for ACSR conductor without current loop according to Chapter Q (Technical Specification)

	Conductor size	Overall diameter
a)	70/12 mm²	11.5 mm
b)	120/20 mm²	15.5 mm
c)	185/30 mm²	19.0 mm



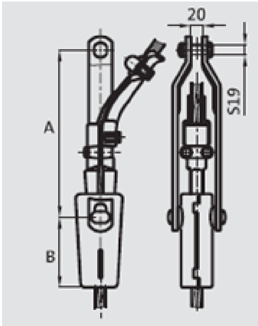
Used for support conductor ACSR

Comment

C16

WEDGE TYPE TENSION CLAMP, for ACSR conductor with current loop according to Chapter Q (Technical Specification)

	Conductor size	Overall diameter
a)	70/12 mm²	11.5 mm
b)	120/20 mm²	15.5 mm
c)	185/30 mm²	19.0 mm

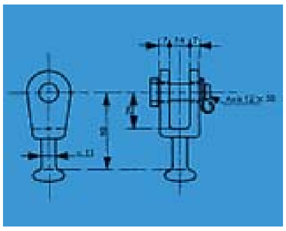


Used for support conductor ACSR

B4

BALL CLEVIS, galvanized steel for suspension insulator I1 according to Chapter Q (Technical Specification)

	Minimum Breaking strength
a)	130 kN

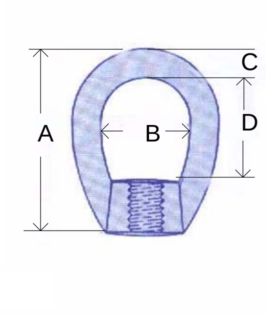


Used for support conductor ACSR

N3

EYE NUT, galvanized steel according to Chapter Q (Technical Specification)

	For bolt Diameter	Minimum Breaking strength
a)	M16	130 kN

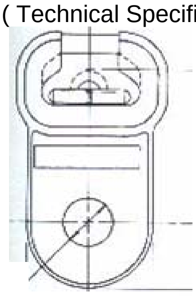


Used for support conductor ACSR

E1

SOCKET EYE STRAIGHT, galvanized steel for suspension insulator I1 according to Chapter Q (Technical Specification)

	Minimum Breaking strength
a)	130 kN



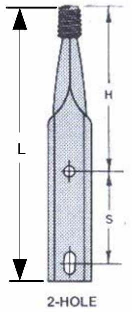
Used for support conductor ACSR

Comment

P1

POLE TOP PIN, galvanized pressed steel for pin type insulator I2 according to Chapter Q (Technical Specification)

	Dimensions				
	L	H	S	Hole diameter	Slotted hole
a)	500 mm	280 mm	200 mm	18 mm	18 mm x 32 mm

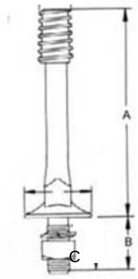


Used for support conductor on pole Medium Voltage

P2

SHORT SHANK PIN, galvanized forged steel with nut and spring lock washer included for pole top insulator I2 according to Chapter Q (Technical Specification)

	Dimensions			
	A	B	C	Shank diameter
a)	180 mm	40 mm	75 mm	M20

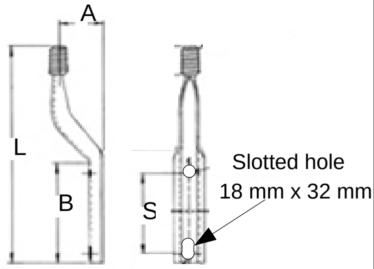


Used for support conductor on cross arm Medium Voltage

P3

OFFSET POLE TOP PIN, galvanized pressed steel for pin type insulator I2 according to Chapter Q (Technical Specification)

	Dimensions				
	L	A	B	S	Hole diameter
a)	550 mm	110 mm	300 mm	200 mm	18 mm

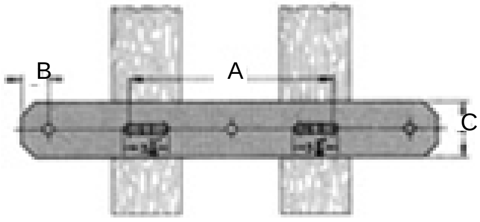


Used for support conductor on pole Medium Voltage

P4

DOUBLE ARMING PLATE, hot dip galvanized short shank pin P2 according to Chapter Q (Technical Specification)

	Dimensions				
	L	A	B	C	Hole diameter
a)	600 mm	370 mm	50 mm	100 mm	22 mm



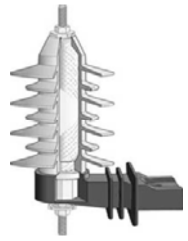
Used for mounting short shank insulator pin

Comment

A1

SURGE ARRESTER, type gapless, grey, silicon rubber, insulated bracket according to Chapter P (Technical Specification)

	Rated max. operating voltage	Rated continuous operating voltage	Rated discharge current (peak)	Rated frequency
a)	24 kV	19 kV	10 kA	50 Hz



Used for overvoltage protection

B1

DOUBLE ARMING BOLT , metric thread, 4 hexagonal nut, galvanized steel according to Chapter B (Technical Specification)

	Dimensions		Minimum
	Diameter	Length	Breaking strength
a)	M16	250 mm	55 kN
b)	M16	300 mm	55 kN
c)	M16	350 mm	55 kN
d)	M16	400 mm	55 kN
e)	M20	300 mm	80 kN
f)	M20	350 mm	80 kN
g)	M16	500 mm	55 kN
h)	M16	550 mm	55 kN

Used for assemblies double cross arm

B2

MACHINE BOLT, metric thread, hexagonal head and nut, galvanized steel according to Chapter B (Technical Specification)

	Dimensions		Minimum
	Diameter	Length	Breaking strength
a)	M10	50 mm	19 kN
b)	M10	125 mm	19 kN
c)	M12	50 mm	35 kN
d)	M12	150 mm	35 kN
e)	M12	250 mm	35 kN
f)	M12	300 mm	35 kN
g)	M16	200 mm	55 kN
h)	M16	250 mm	55 kN
i)	M16	300 mm	55 kN
j)	M20	250 mm	80 kN
k)	M20	300 mm	80 kN
l)	M20	350 mm	80 kN
m)	M20	50 mm	80 kN
n)	M12	475 mm	35 kN
o)	M12	525 mm	35 kN

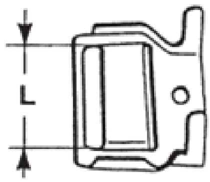
Used for assemblies single cross arm, pole top pin

Comment

B5

BUCKLE FOR STRAPS, stainless steel according to Chapter B (Technical Specification)

	Dimensions L
a)	21 mm



Use with straps S8

Used for attach cables protection

C17

COPPER CONDUCTOR, stranded according to Chapter S (Technical Specification)

	Conductor size	Overall diameter
a)	25 mm²	6.40 mm
b)	35 mm²	7.60 mm

Used for earthing electrical system

C18

GROUND ROD CLAMP, copper bonded according to Chapter S (Technical Specification)

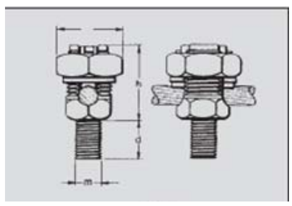
	Rod diameter	Conductor range
a)	12 mm	25 mm²
b)	16 mm	35 mm²

Used for connect earthwire to the ground rod

C19

GROUND STUD CONNECTOR (SPLIT BOLT), copper bonded according to Chapter S (Technical Specification)

	Stud diameter	Conductor range
a)	12 mm	25 mm²
b)	12 mm	35 mm²



Used for connect ground lug pole inside to external ground

Comment

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	MISCELLANEOUS	
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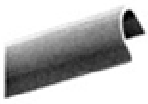
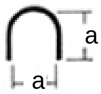
G1

GROUND WIRE MOLDING GUARD, plastic, grey color according to Chapter B (Technical Specification)

	Dimension	
	a	Length
a)	12 mm	2400 mm





Used for protecting of ground wire

R1

GROUND ROD, copper bonded according to Chapter S (Technical Specification)

	Dimensions	
	Diameter	Length
a)	12 mm	1500 mm
b)	16 mm	1800 mm

Used for connect earthwire to the ground

S7

STRAP, hot dip galvanized, include plastic anchor and slotted hex head with washer head screw according to Chapter B (Technical Specification)

	For guard	Anchor and slotted length
a)	12 mm	25 mm


strap


Slotted


Anchor

Used for protecting ground wire

S8

STRAPS, stainless steel according to Chapter B (Technical Specification)

	Dimensions	Breaking strength
a)	20 mm x 0.4 mm	70 daN/mm²

Used for attach cables protection

Comment

S9

FACADE SADDLES , include a plastic support, a plastic plug, a standard plastic tie and galvanized steel according to Chapter B (Technical Specification)

For cable size

a) ABC 3 x 120 mm² + 1 x 70 mm²

Used to install LV insulated overhead line on a building

W1

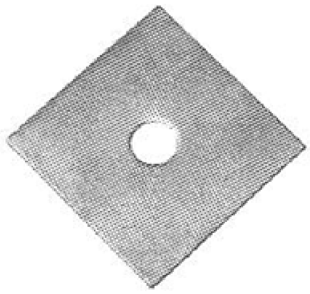
ROUND WASHER , galvanized steel according to Chapter B (Technical Specification)

	For Bolt Diameter	Outside Diameter	Thickness
a)	M12	35 mm	6 mm
b)	M16	45 mm	6 mm
c)	M20	50 mm	6 mm

Used for miscellaneous assemblies

W2

SQUARE WASHER , galvanized steel according to Chapter B (Technical Specification)



	For Bolt Diameter	Size
a)	M10	50 mm x 50 mm x 3mm
b)	M12	60 mm x 60 mm x 8 mm
c)	M16	75 mm x 75 mm x 8 mm
d)	M20	100 mm x 100 mm x 10 mm

Used for miscellaneous assemblies

W3

SPRING LOCK WASHER , galvanized steel according to Chapter B (Technical Specification)

	For Bolt Diameter	Inside diameter Min.	Inside diameter Max.
a)	M10	10.5 mm	10.7 mm
b)	M12	12.7 mm	13.0 mm
c)	M16	16.9 mm	17.3 mm
d)	M20	20.1 mm	20.7 mm

Used for keep a bolt-nut in tension

Comment

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Rehabilitation and extension of the Kabul City distrubution Network

DISTRIBUTION CONSTRUCTION MATERIALS

GUY

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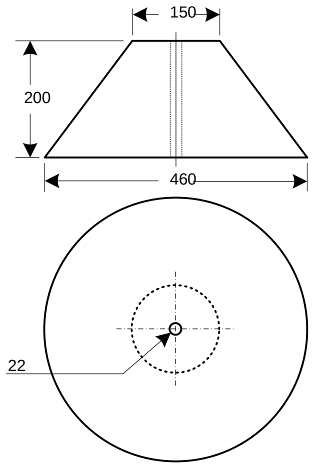
A2

CONE ANCHOR, concrete

	Area	Weight	Ultimate strenght	For Rod Diameter
a)	161300 mm²	380 N	130 kN	20 mm

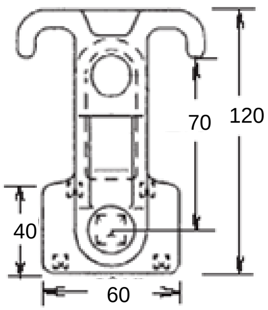


Used for guy assembly

G2

GUY HOOD , ductile iron, hot dip galvanized according to Chapter B (Technical Specification)

	Guy end diameter	Thru bolt	ultimate strength rating
a)	7.0 mm	M16	39 kN
b)	11.0 mm	M20	95 kN

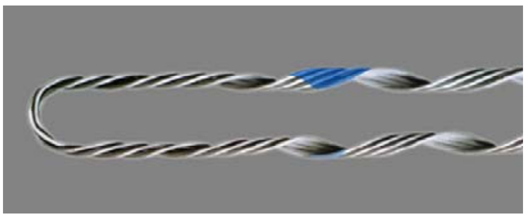


Used for guy assembly

G3

GUY END , galvanized steel according to Chapter B (Technical Specification)

	For guy diameter	ultimate strength rating
a)	7.0 mm	36 kN
b)	11.0 mm	101 kN



Used for guy assembly

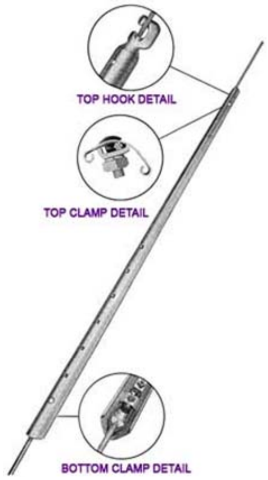
Comment

G4

TAPERED GUY (GUARD), half round steel with top clamp according to Chapter B (Technical Specification)

	For guy range diameter	Lenght
a)	6.0 - 11.0 mm	2400 mm

Used for protecting guy wire



N4

THIMBLEYENUT, galvanized steel according to Chapter Q (Technical Specification)

	For bolt Diameter	Guy end diameter	Minimum Breaking strength
a)	M16	7.0 mm	100 kN
b)	M20	11.0 mm	130 kN

Used for guy assembly

R3

THIMBLEYE ANCHOR ROD , galvanized steel with nut included according to Chapter B (Technical Specification)

	Diameter	Lenght	ultimate strength rating
a)	M16	2000 mm	70 kN
b)	M20	2400 mm	100 kN

Used for guy assembly

Comment

R4

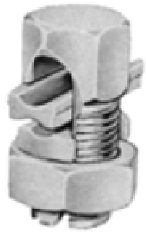
TWINEYE ANCHOR ROD , galvanized steel with nut included according to Chapter B (Technical Specification)

	Diameter	Lenght	ultimate strength rating
a)	M20	2400 mm	100 kN

Used for guy assembly

S12

SPLIT BOLT , copper to galvanized steel, high strength, high copper, alloy body, electrotined nut, spacer and pressure bar according to Chapter B (Technical Specification)



	Guy strand diameter	Copper strand diameter
a)	7.0 mm	6.40 mm
b)	11.0 mm	7.60 mm

Used for connect guy wire to the ground

W4

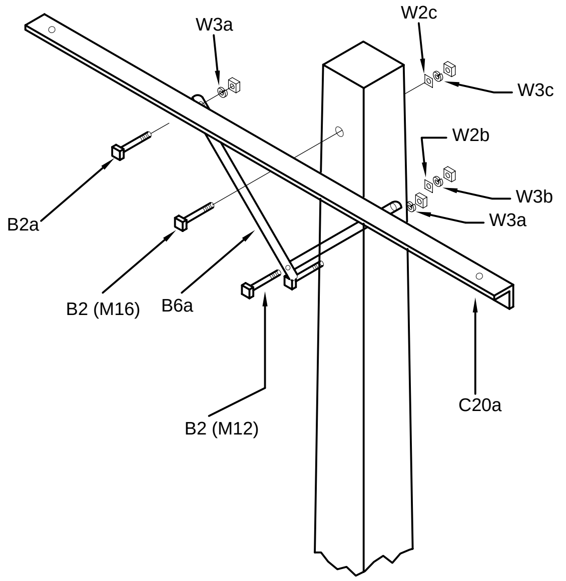
GUY WIRE , zinc-coated steel stranded, 1300 grade according to Chapter B (Technical Specification)

	Wire size	Strand diameter	ultimate strength rating
a)	7 X 2.00 mm	7.0 mm	39 kN
b)	7 X 3.65 mm	11.0 mm	95 kN

Used for guy assembly

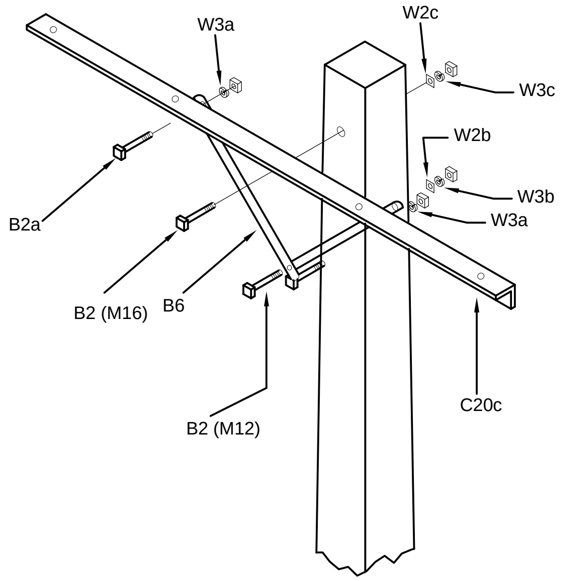
Comment

AS-01	SINGLE CROSSARM STEEL (2000 mm)
AS-02	SINGLE CROSSARM STEEL (3200 mm)
AS-03	DOUBLE CROSSARM STEEL (2000 mm)
AS-04	DOUBLE CROSSARM STEEL (3200 mm)
AS-05	SINGLE SUPPORT ON CROSSARM (TANGENT)
AS-06	DOUBLE SUPPORT ON CROSSARM (ANGLE)
AS-07	SINGLE SUPPORT ON TOP POLE
AS-08	DOUBLE SUPPORT ON TOP POLE
AS-09	DEADEND ON CROSSARM
AS-10	DEADEND ON POLE
AS-11	LV – SINGLE SUPPORT
AS-12	LV - SINGLE DEADEND
AS-13	LV – SINGLE DEADEND (existing spiral hook)
AS-14	LV – DOUBLE SUPPORT (angle up to 60º)
AS-15	LV – SINGLE SUPPORT (External angle)



NO.	QT.	DESCRIPTION	CODE
B2a	2	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M10 x 50 mm	
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M12 x REQ`D LENGTH	
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x REQ`D LENGTH	
B6a	2	FLAT CROSSARM BRACE 40 mm X 8 mm, LENGTH 760 mm	
C20a	1	STEEL CROSSARM 70 mm X 70 mm X 7 mm, LENGTH 2000 mm	
W2b	1	SQUARE WASHER, 60 mm X 60 mm X 8 mm, FOR BOLT M12	
W2c	1	SQUARE WASHER, 75 mm X 75 mm X 8 mm, FOR BOLT M16	
W3a	2	SPRING LOCK WASHER, FOR BOLT M10	
W3b	1	SPRING LOCK WASHER, FOR BOLT M12	
W3c	1	SPRING LOCK WASHER, FOR BOLT M16	

Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single crossarm steel (2000 mm) Miscellaneous assemblies MV		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without
		U	**AS-01**



NO.	QT.	DESCRIPTION	CODE
B2a	2	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M10 x 50 mm	
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M12 x REQ`D LENGTH	
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x REQ`D LENGTH	
B6b	2	FLAT CROSSARM BRACE 40 mm X 8 mm, LENGTH 1000 mm	
C20c	1	STEEL CROSSARM 70 mm X 70 mm X 7 mm, LENGTH 3200 mm	
W2b	1	SQUARE WASHER, 60 mm X 60 mm X 8 mm, FOR BOLT M12	
W2c	1	SQUARE WASHER, 75 mm X 75 mm X 8 mm, FOR BOLT M16	
W3a	2	SPRING LOCK WASHER, FOR BOLT M10	
W3b	1	SPRING LOCK WASHER, FOR BOLT M12	
W3c	1	SPRING LOCK WASHER, FOR BOLT M16	

Ministry of Water and Power
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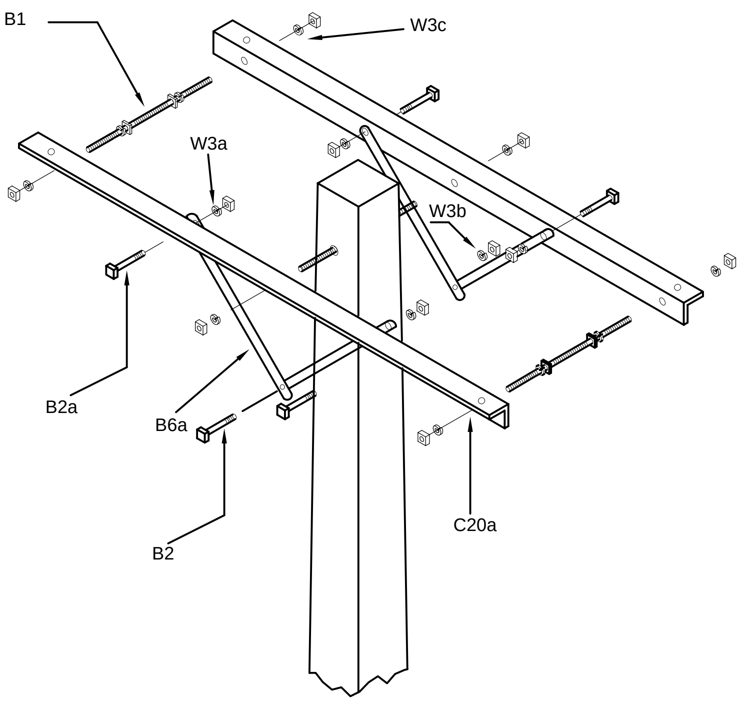
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Single crossarm steel (3200 mm)
Miscellaneous assemblies MV

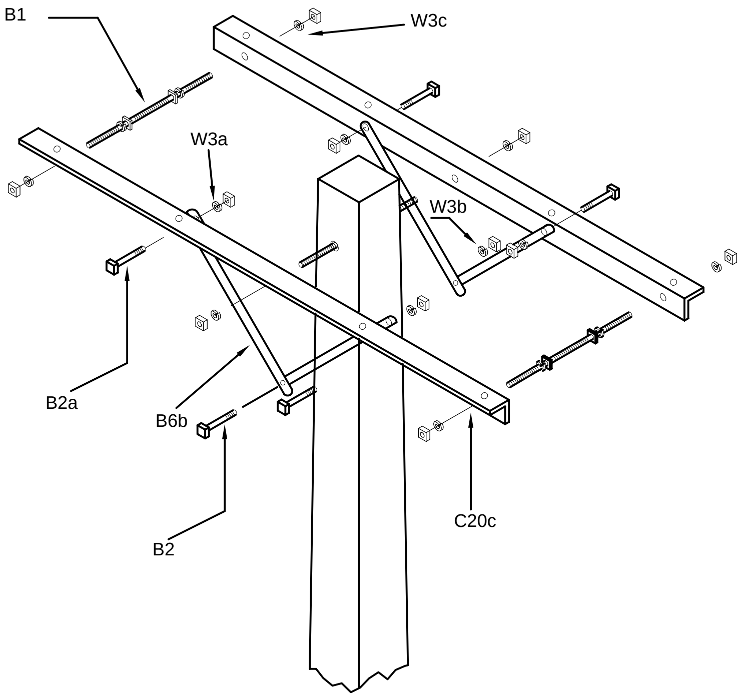
Date: January, 2005 | Revision: 1 | Scale: Without

Drawing: U **AS-02**



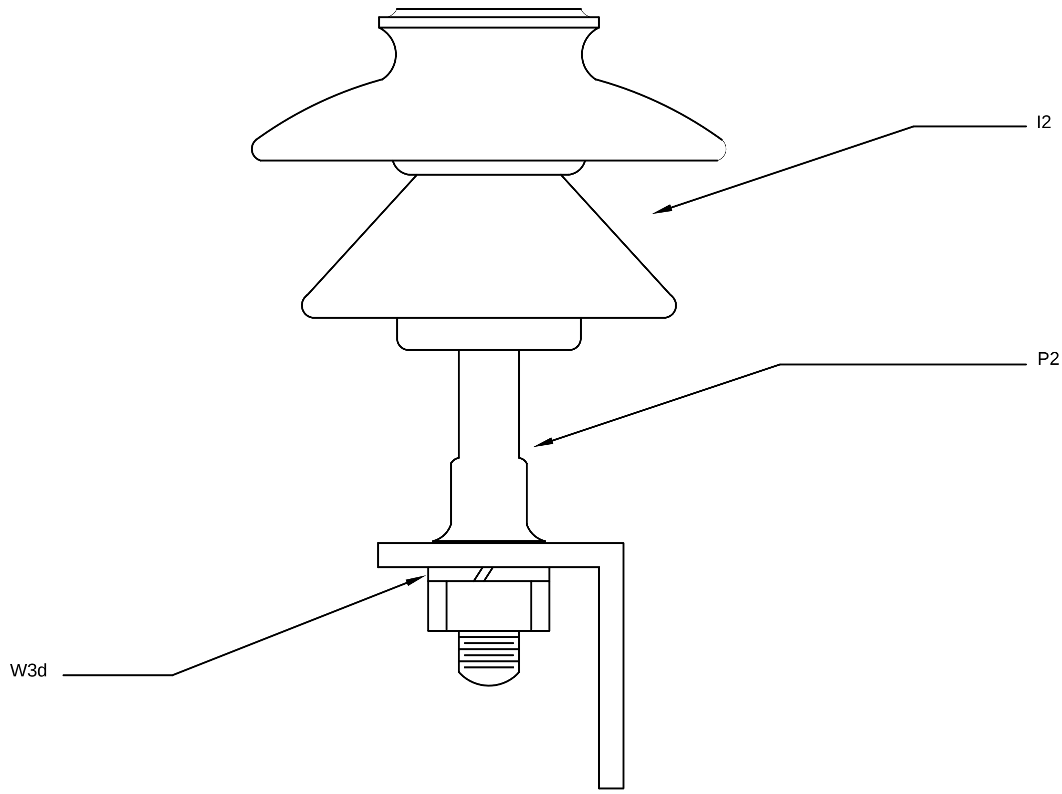
NO.	QT.	DESCRIPTION	CODE
B1	3	DOUBLE ARMING BOLT, METRIC THREAD, 4 HEXAGONAL NUT M16 x REQ`D LENGTH	
B2a	4	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M10 x 50 mm	
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M12 x REQ`D LENGTH	
B6a	4	FLAT CROSSARM BRACE 40 mm X 8 mm, LENGTH 760 mm	
C20a	2	STEEL CROSSARM 70 mm X 70 mm X 7 mm, LENGTH 2000 mm	
W3a	4	SPRING LOCK WASHER, FOR BOLT M10	
W3b	1	SPRING LOCK WASHER, FOR BOLT M12	
W3c	10	SPRING LOCK WASHER, FOR BOLT M16	

Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Double crossarm steel (2000 mm) Miscellaneous assemblies MV			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U **AS-03**



NO.	QT.	DESCRIPTION	CODE
B1	3	DOUBLE ARMING BOLT, METRIC THREAD, 4 HEXAGONAL NUT M16 x REQ`D LENGTH	
B2a	4	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M10 x 50 mm	
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M12 x REQ`D LENGTH	
B6b	4	FLAT CROSSARM BRACE 40 mm X 8 mm, LENGTH 1000 mm	
C20c	2	STEEL CROSSARM 70 mm X 70 mm X 7 mm, LENGTH 3200 mm	
W3a	4	SPRING LOCK WASHER, FOR BOLT M10	
W3b	1	SPRING LOCK WASHER, FOR BOLT M12	
W3c	10	SPRING LOCK WASHER, FOR BOLT M16	

Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Double crossarm steel (3200 mm) Miscellaneous assemblies MV		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	**U** **AS-04**



NO.	QT.	DESCRIPTION	CODE
I2	1	PIN TYPE INSULATOR, 238 mm (DIAMETER) X 158 mm (HEIGHT)	
P2	1	SHORT SHANK PIN, FOR POLE TOP INSULATOR I2	
W3d	1	SPRING LOCK WASHER, FOR BOLT M20	

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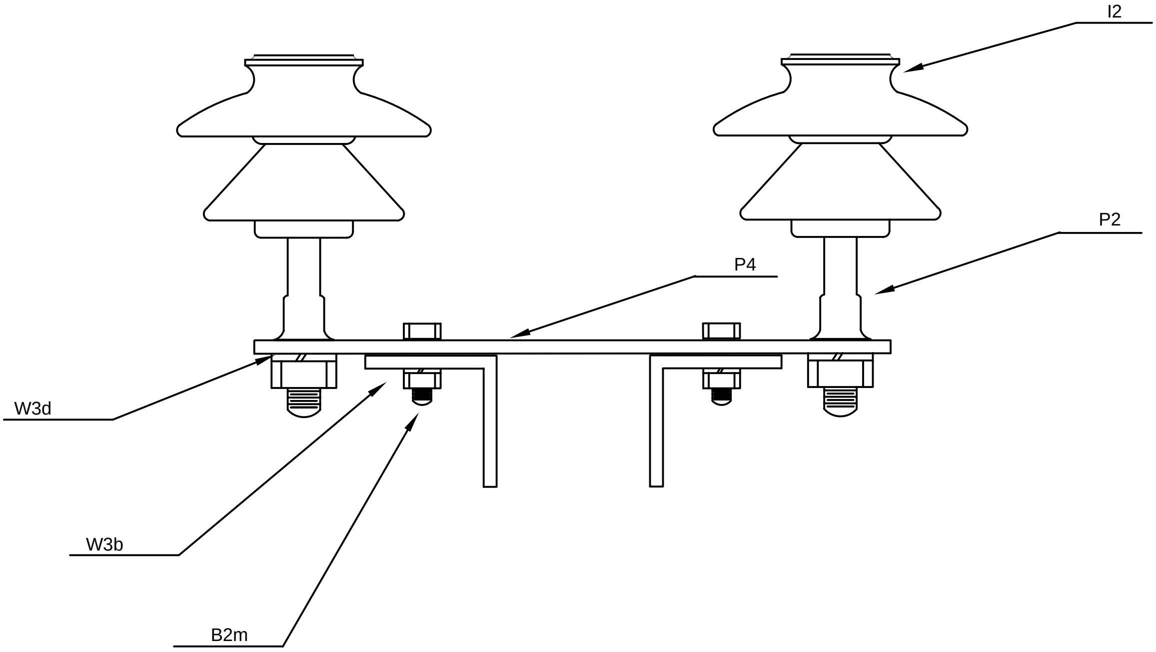
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Single support on crossarm (tangent)
Miscellaneous assemblies MV

Date: January, 2005 | Revision: 1 | Scale: Without

Drawing: U AS-05



NO.	QT.	DESCRIPTION	CODE
B2m	2	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M20 x 50 mm	
I2	2	PIN TYPE INSULATOR, 238 mm (DIAMETER) X 158 mm (HEIGHT)	
P2	2	SHORT SHANK PIN, FOR POLE TOP INSULATOR I2	
P4	1	DOUBLE ARMING PLATE, FOR SHORT SHANK PIN P2	
W3d	4	SPRING LOCK WASHER, FOR BOLT M20	

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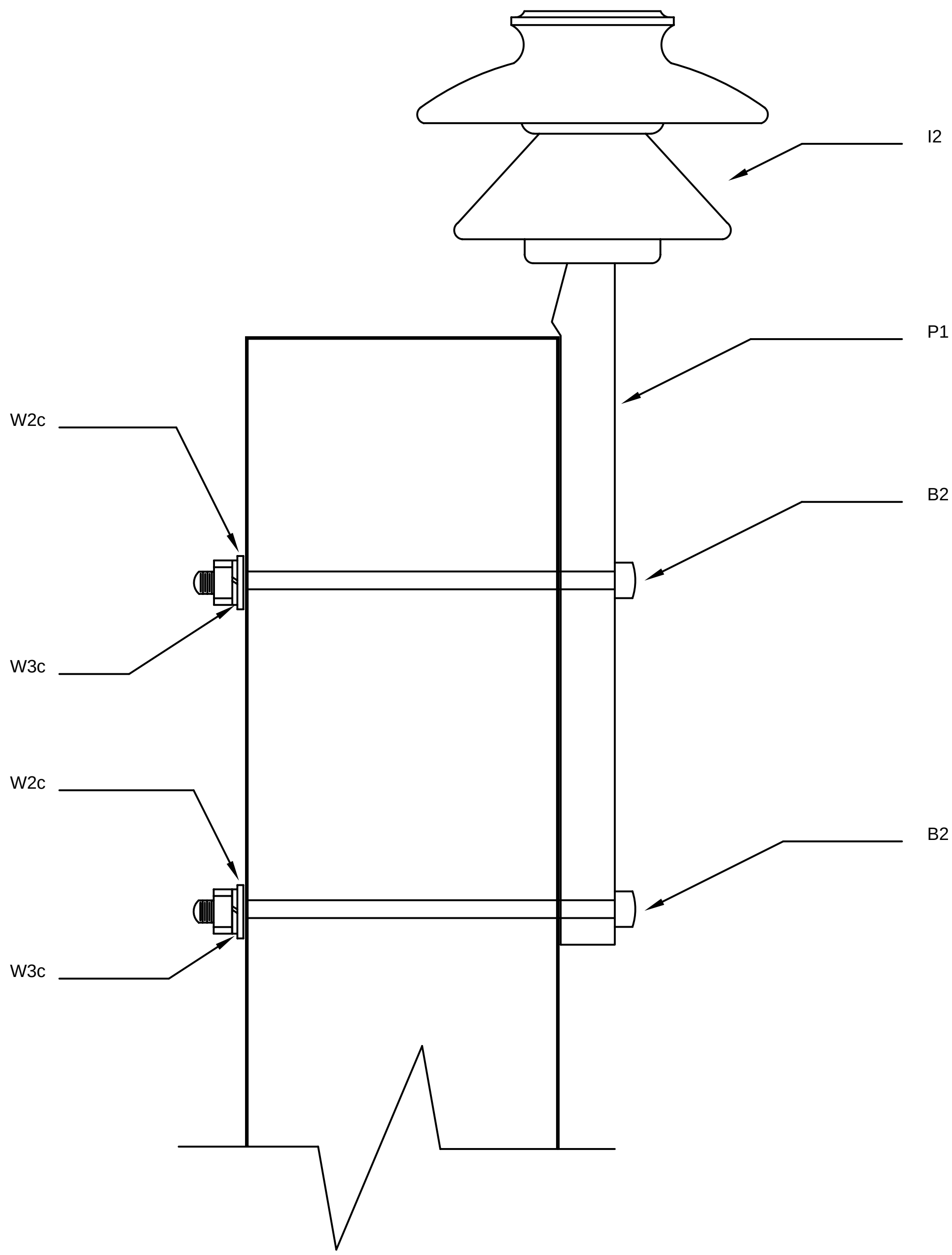
Rehabilitation and Extension of Kabul City Distribution Network

Double support on crossarm (angle)
Miscellaneous assemblies MV

Date: January, 2005 | Revision: 1 | Scale: Without

Drawing:
U **AS-06**



NO.	QT.	DESCRIPTION	CODE
B2	2	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x REQ`D LENGTH	
I2	1	PIN TYPE INSULATOR, 238 mm (DIAMETER) X 158 mm (HEIGHT)	
P1	1	POLE TOP PIN, 500 mm X 280 mm X 200 mm	
W2c	2	SQUARE WASHER, 75 mm X 75 mm X 8 mm, FOR BOLT M16	
W3c	2	SPRING LOCK WASHER, FOR BOLT M16	

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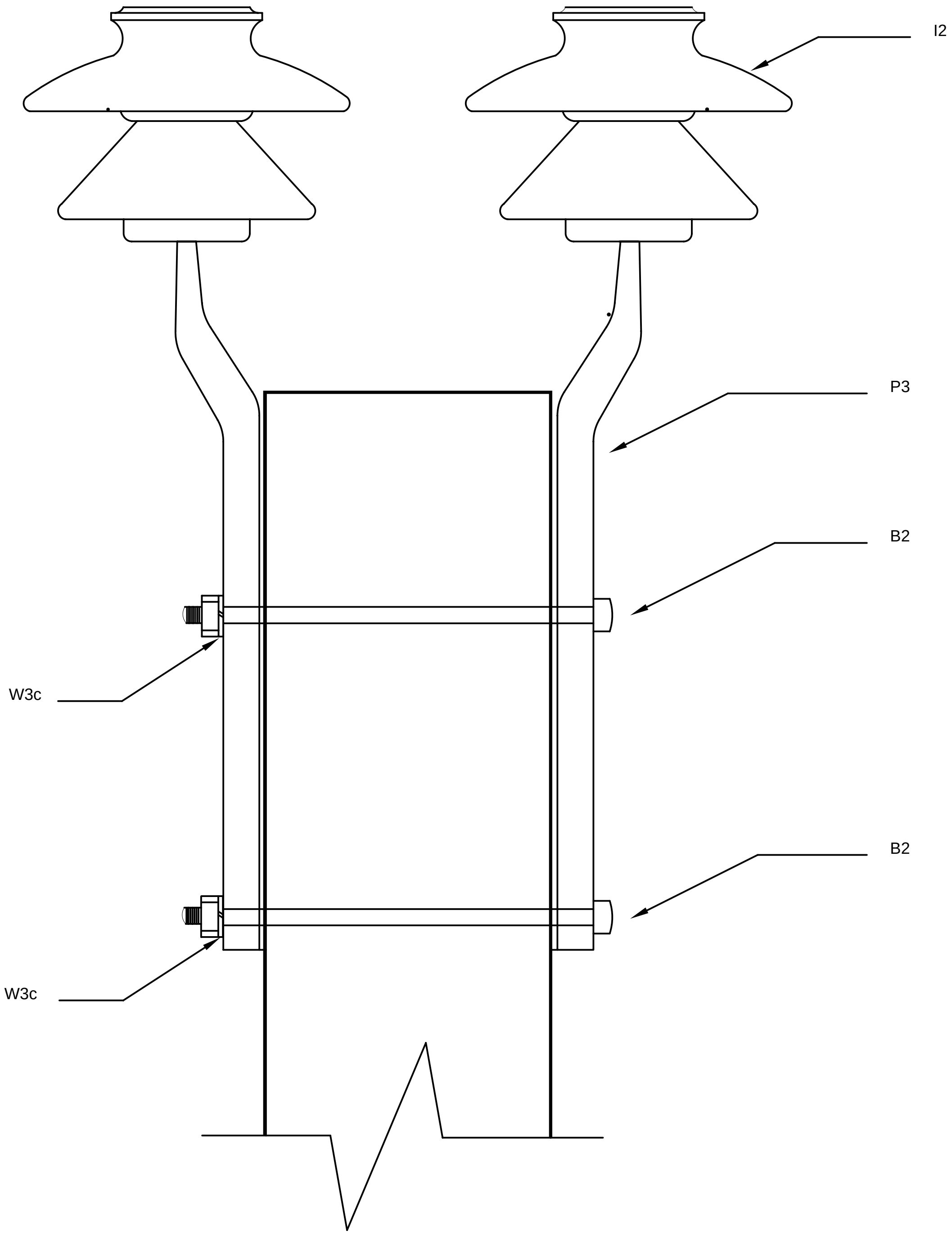
MWP

Rehabilitation and Extension of Kabul City
Distribution Network

Single support on top pole
Miscellaneous assemblies MV

Date: January, 2005 | Revision: 1 | Scale: Without

Drawing: U **AS-07**



NO.	QT.	DESCRIPTION	CODE
B2	2	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x REQ`D LENGTH	
I2	2	PIN TYPE INSULATOR, 238 mm (DIAMETER) X 158 mm (HEIGHT)	
P3	2	OFFSET POLE TOP PIN, 550 mm X 110 mm X 200 mm	
W3c	2	SPRING LOCK WASHER, FOR BOLT M16	

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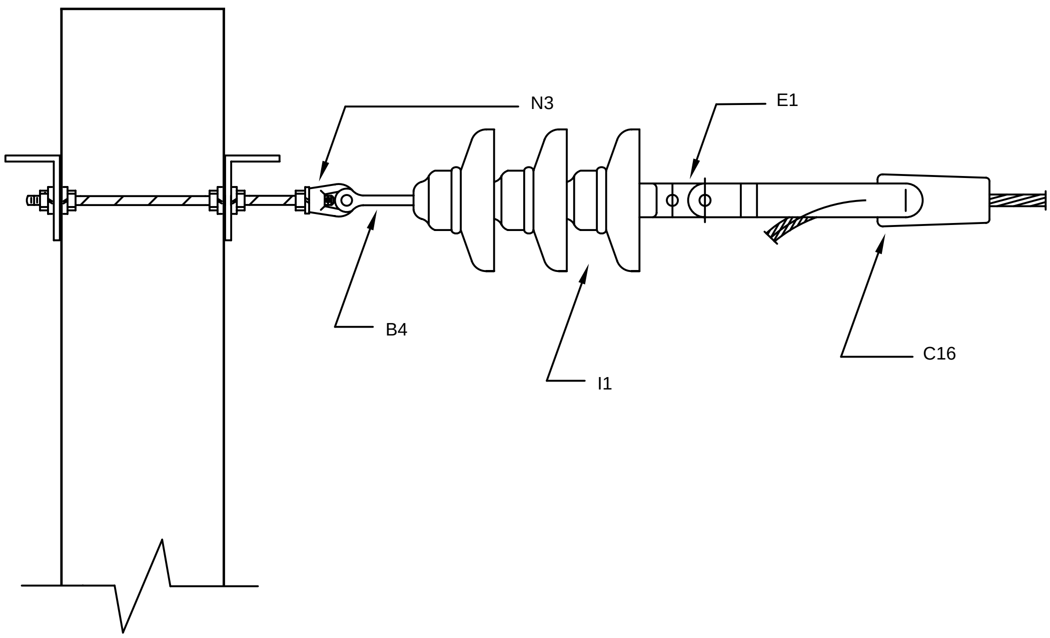
MWP

Rehabilitation and Extension of Kabul City
Distribution Network

Double support on top pole
Miscellaneous assemblies MV

Date: January, 2005 | Revision: 1 | Scale: Without

Drawing: U AS-08



NO.	QT.	DESCRIPTION	CODE
B4	1	BALL CLEVIS, FOR SUSPENSION INSULATOR I1	
C16	1	WEDGE TYPE TENSION CLAMP, FOR ACSR CONDUCTOR	
E1	1	SOCKET EYE STRAIGHT, FOR SUSPENSION INSULATOR I1	
I1	3	SUSPENSION INSULATOR, BALL AND SOCKET 175 mm (DISC. DIAMETER) X 110 mm (SPACING)	
N3	1	EYE NUT, FOR BOLT M16	

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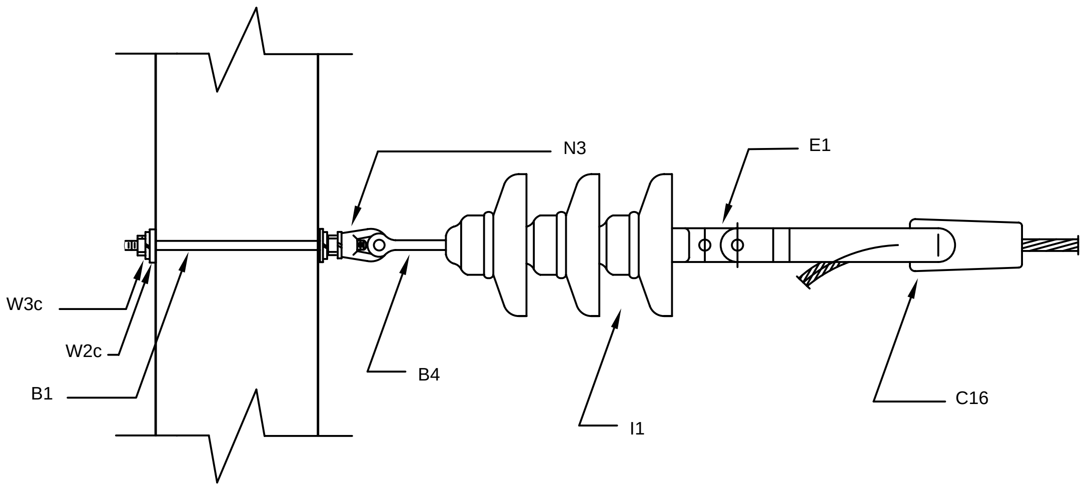
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Deadend on crossarm
Miscellaneous assemblies MV

Date: January, 2005 | Revision: 1 | Scale: Without

Drawing: U AS-09



NO.	QT.	DESCRIPTION	CODE
B1	1	DOUBLE ARMING BOLT, METRIC THREAD, 4 HEXAGONAL NUT M16 x REQ`D LENGTH	
B4	1	BALL CLEVIS, FOR SUSPENSION INSULATOR I1	
C16	1	WEDGE TYPE TENSION CLAMP, FOR ACSR CONDUCTOR	
E1	1	SOCKET EYE STRAIGHT, FOR SUSPENSION INSULATOR I1	
I1	3	SUSPENSION INSULATOR, BALL AND SOCKET 175 mm (DISC. DIAMETER) X 110 mm (SPACING)	
N3	1	EYE NUT, FOR BOLT M16	
W2c	2	SQUARE WASHER, 75 mm X 75 mm X 8 mm, FOR BOLT M16	
W3c	2	SPRING LOCK WASHER, FOR BOLT M16	

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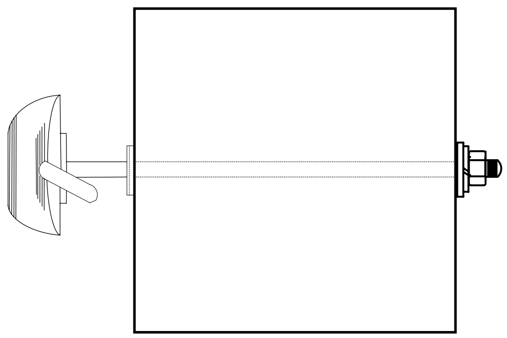
MWP

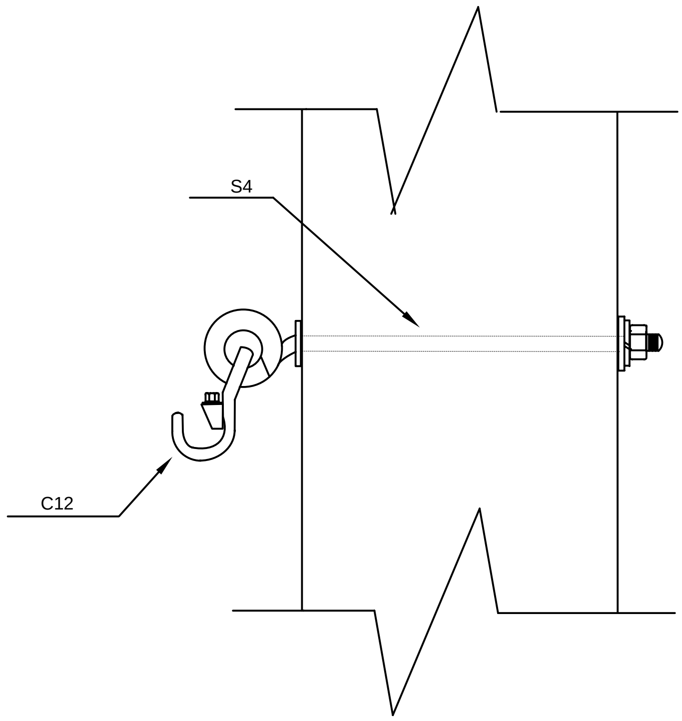
Rehabilitation and Extension of Kabul City
Distribution Network

Deadend on pole
Miscellaneous assemblies MV

Date: January, 2005 | Revision: 1 | Scale: Without

Drawing: U **AS-10**





NO.	QT.	DESCRIPTION	CODE
C12	1	SUSPENSION CLAMP, FOR NON-INSULATED NEUTRAL AAAC	
S4	1	SPIRAL (PIG TAIL) HOOK, WITH SQUARE WASHER, SPRING LOCK WASHER AND NUT	

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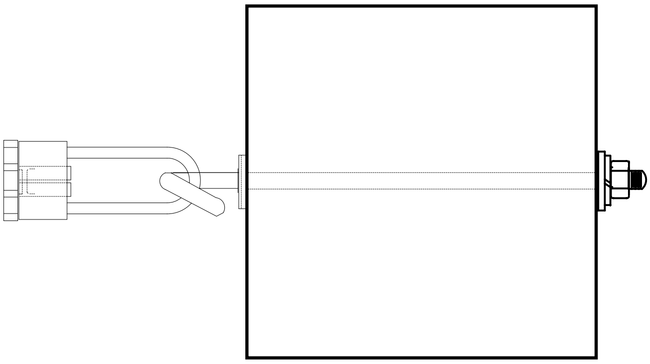
MWP

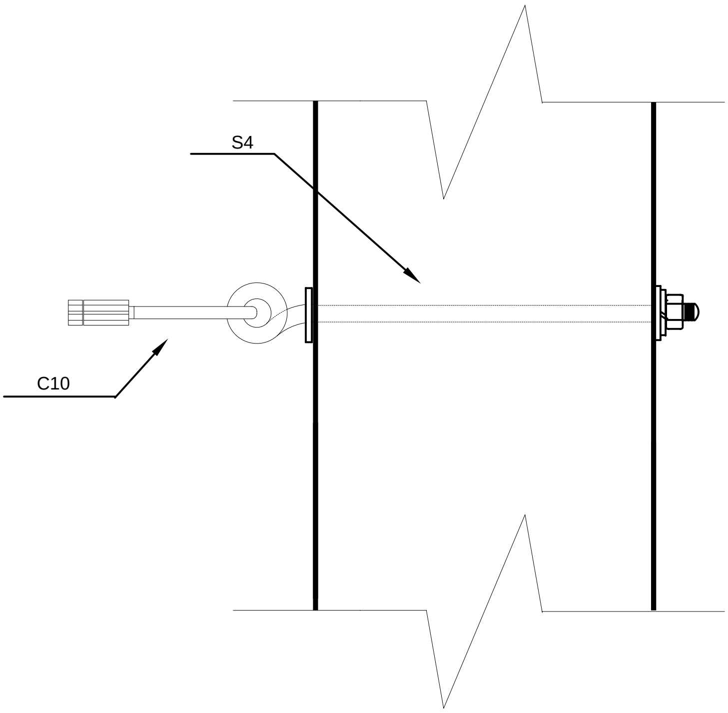
Rehabilitation and Extension of Kabul City Distribution Network

Single support
Miscellaneous assemblies LV

Date: March, 2005 | Revision: 0 | Scale: Without

Drawing: U **AS-11**





NO.	QT.	DESCRIPTION	CODE
C10	2	DEAD END CLAMP, FOR NON-INSULATED NEUTRAL AAAC	
S4	1	SPIRAL (PIG TAIL) HOOK M16, WITH SQUARE WASHER, SPRING LOCK WASHER AND NUT	

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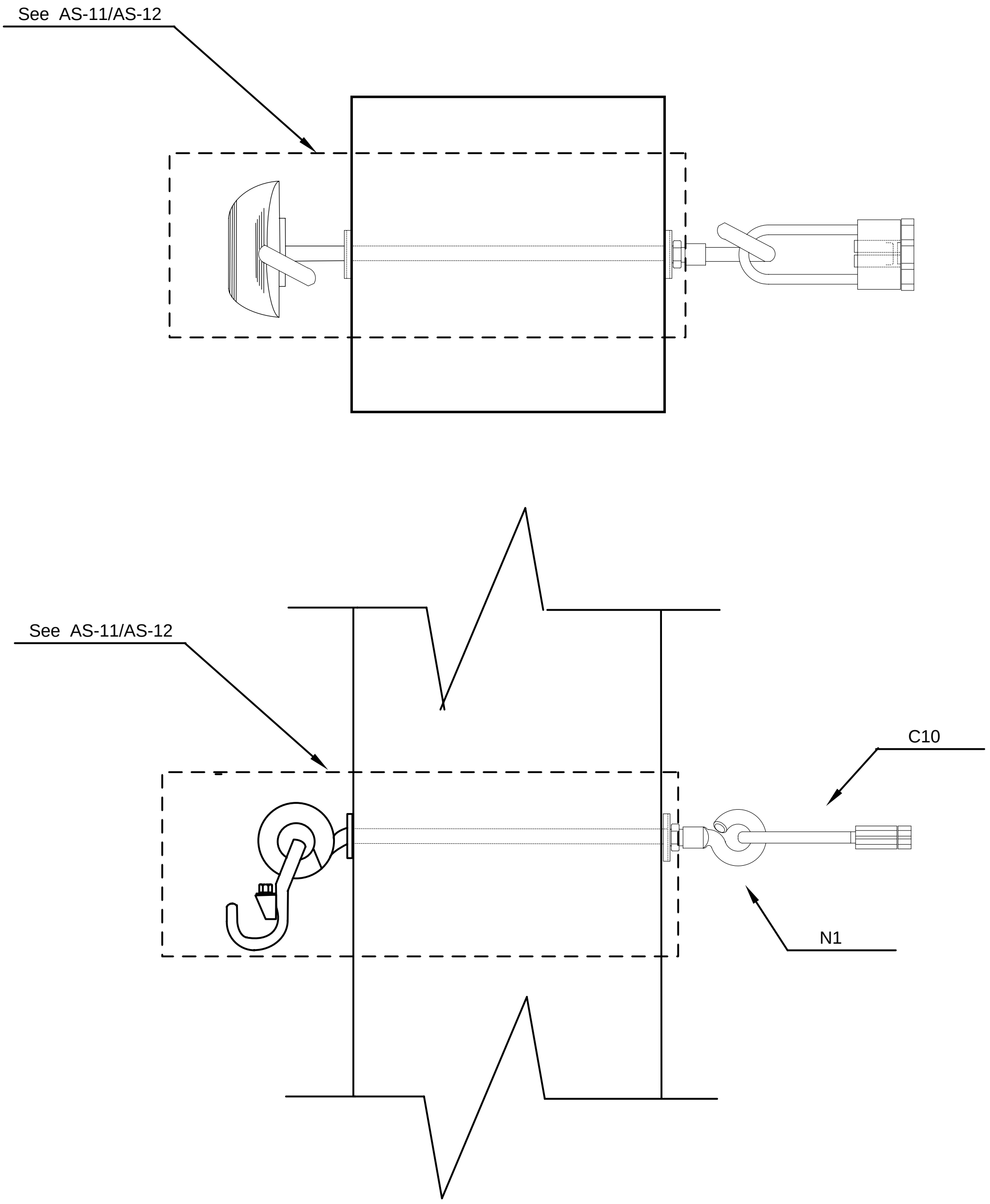
MWP

Rehabilitation and Extension of Kabul City
Distribution Network

Single deadend
Miscellaneous assemblies LV

Date: March, 2005 | Revision: 0 | Scale: Without

Drawing: U **AS-12**



NO.	QT.	DESCRIPTION	
C10	1	DEAD END CLAMP, FOR NON-INSULATED NEUTRAL AAAC	
N1	1	NUT HOOK FOR BOLT M16	

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MWP

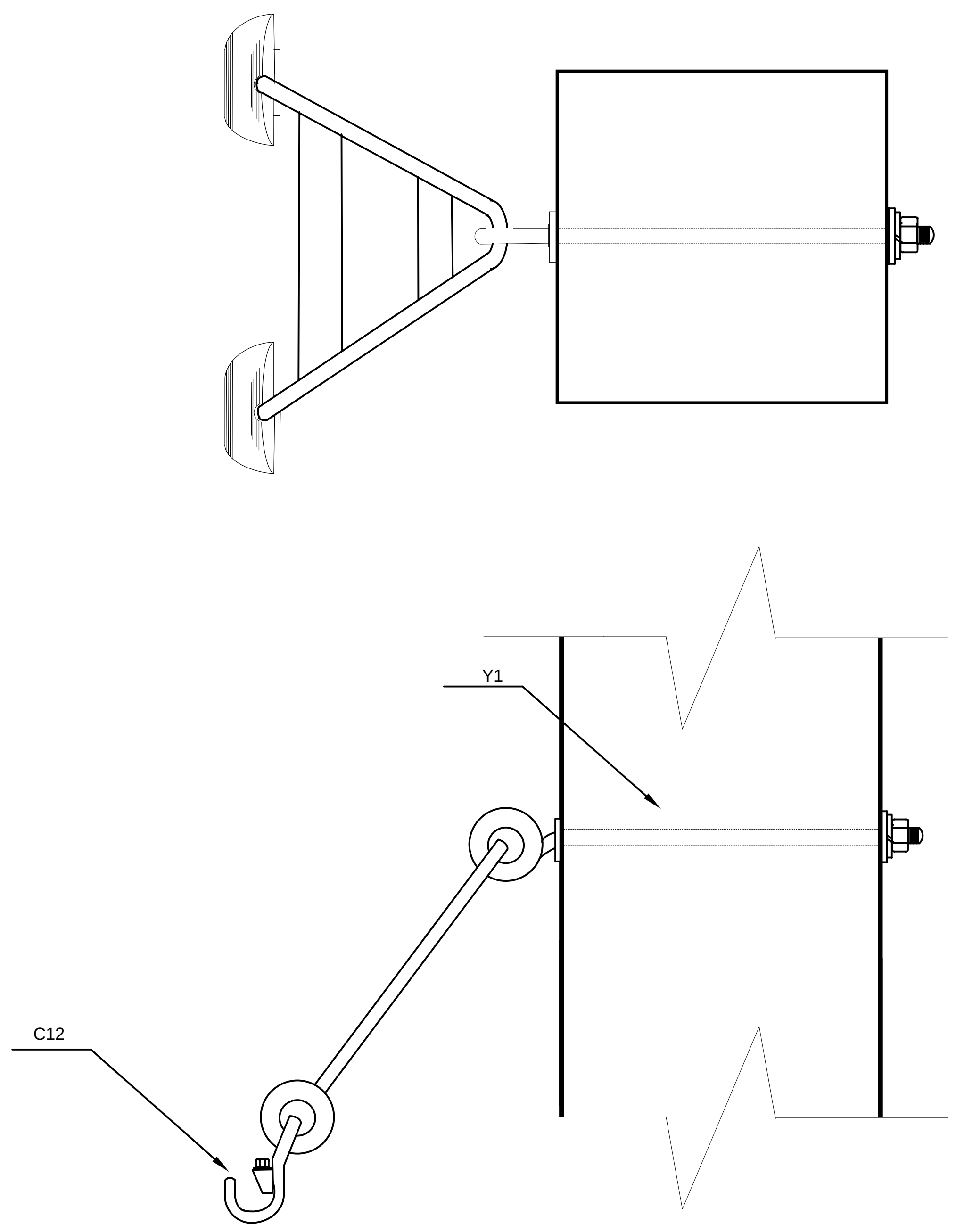
Rehabilitation and Extension of Kabul City
Distribution Network

Single deadend (existing spiral hook)
Miscellaneous assemblies LV

Date: March, 2005 | Revision: 0 | Scale: Without

Drawing:

U **AS-13**



NO.	QT.	DESCRIPTION	CODE
C12	2	SUSPENSION CLAMP, FOR NON-INSULATED NEUTRAL AAAC	
Y1	1	YOKE UNIVERSAL,WITH COMPLETE SPIRAL HOOK	

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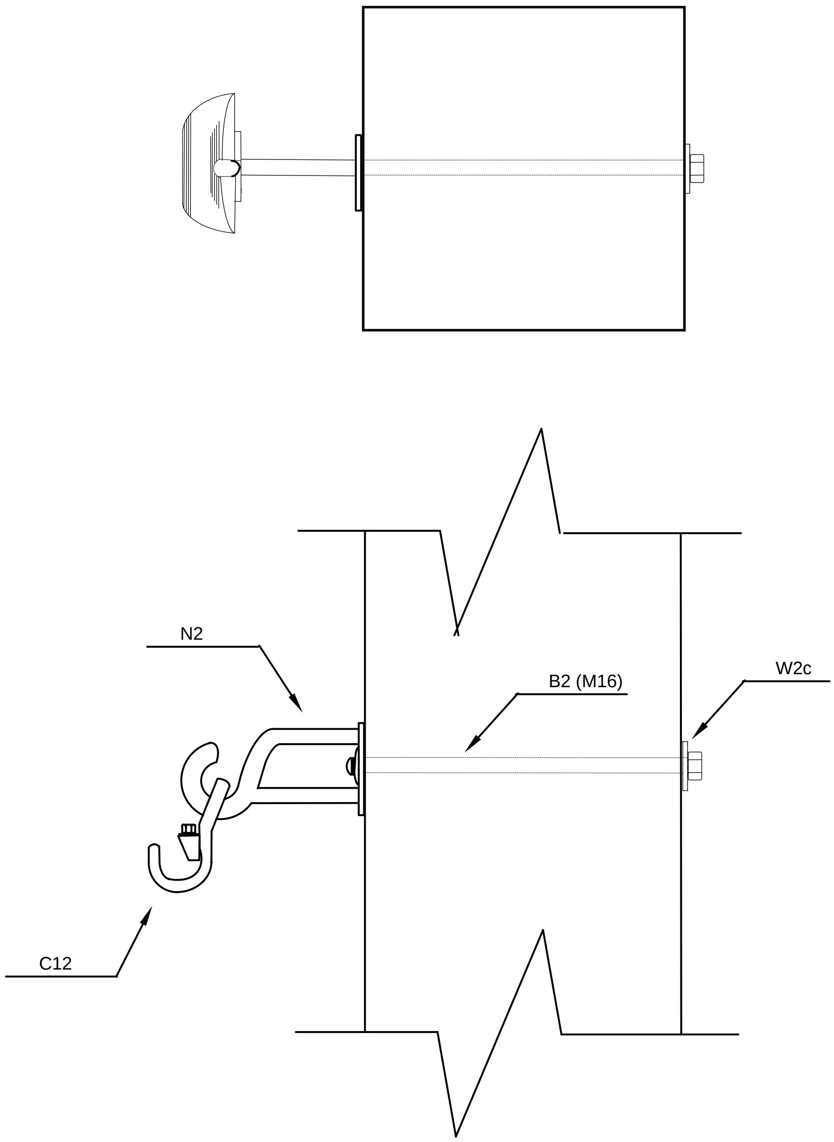
Rehabilitation and Extension of Kabul City Distribution Network

Double support (angle up to 60º)
Miscellaneous assemblies LV

Drawing:

U | AS-14

Date: March, 2005 | Revision: 0 | Scale: Without



NO.	QT.	DESCRIPTION
B2	1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x REQ`D LENGTH
C12	1	SUSPENSION CLAMP, FOR NON-INSULATED NEUTRAL AAAC
N2	1	NUT HOOK (EXTERNAL ANGLE) FOR BOLT M16
W2c	1	SQUARE WASHER, 75 mm X 75 mm X 8 mm, FOR BOLT M16

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Rehabilitation and Extension of Kabul City
Distribution Network

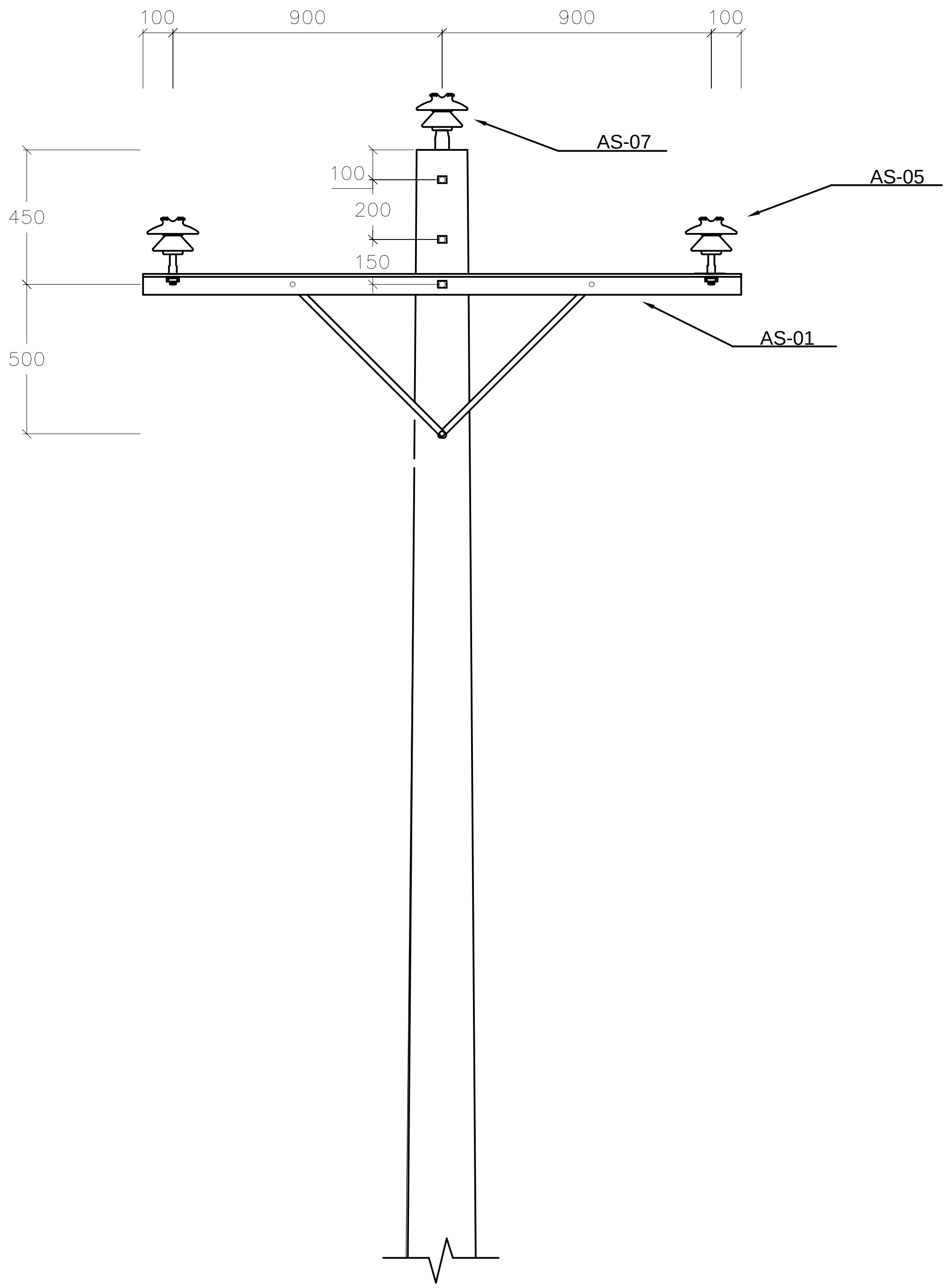
Single support (external angle)
Miscellaneous assemblies LV

Date: March, 2005 | Revision: 0 | Scale: Without

Drawing:

U **AS-15**

MV-301C	SINGLE SUPPORT ON CROSSARM, 3 PHASE, MV
MV-302C	DOUBLE SUPPORT ON CROSSARM (ANGLE 5° TO 15°), 3 PHASE ,MV
MV-303C	DEADEND ANGLE (60° - 90°), 3 PHASE, MV
MV-304C	SINGLE SUPPORT ON CROSSARM WITH TAP GUIDE, 3 PHASE, MV
MV-305C	SINGLE DEADEND ON CROSSARM, 3 PHASE, MV
MV-306C	DOUBLE DEADEND ON CROSSARM, 3 PHASE, MV
MV-307C	DEADEND ON CROSSARM (angle 60º - 90º), 3 PHASE, MV
MV-308C	DEADEND ON CROSSARM (angle 15º - 60º), 3 PHASE, MV
MV-601C	SINGLE SUPPORT ON CROSSARM, DOUBLE CIRCUIT, MV
MV-602C	DOUBLE SUPPORT ON CROSSARM, DOUBLE CIRCUIT, MV
MV-603C	DEADEND ANGLE (60° - 90°), DOUBLE CIRCUIT, MV
MV-604C	SINGLE SUPPORT ON CROSSARM WITH TAP GUIDE, DOUBLE CIRCUIT, MV
MV-605C	SINGLE DEADEND ON CROSSARM, DOUBLE CIRCUIT, MV
MV-606C	DOUBLE DEADEND ON CROSSARM, DOUBLE CIRCUIT, MV
MV-607C	DEADEND ON CROSSARM (angle 15º - 60º), DOUBLE CIRCUIT, MV
T-01	Pole mounted transformer



Assembly	Qty.	Description
AS-01	1	Single crossarm steel (2000 mm)
AS-05	2	Single support on crossarm (tangent)
AS-07	1	Single support on top pole

Material	Qty.	Description
	3	Preformed distribution ties for ACSR

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MWP

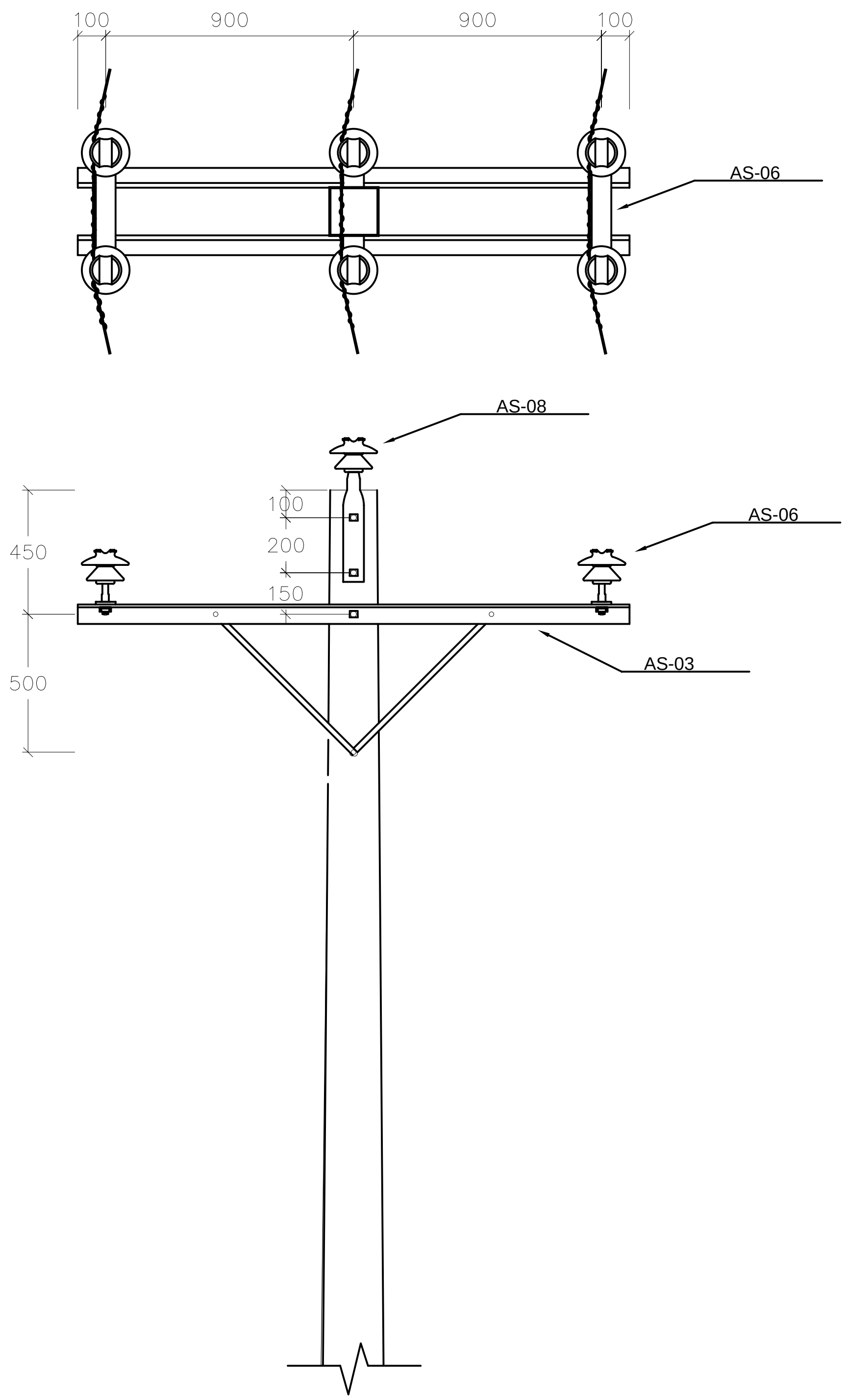
Rehabilitation and Extension of Kabul City
Distribution Network

Single support on crossarm
3 phase, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing:

U **MV-301C**



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-06	2	Double support on crossarm (angle)
AS-08	1	Double support on top pole

Material	Qty.	Description
	6	Preformed distribution ties for ACSR

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MWP

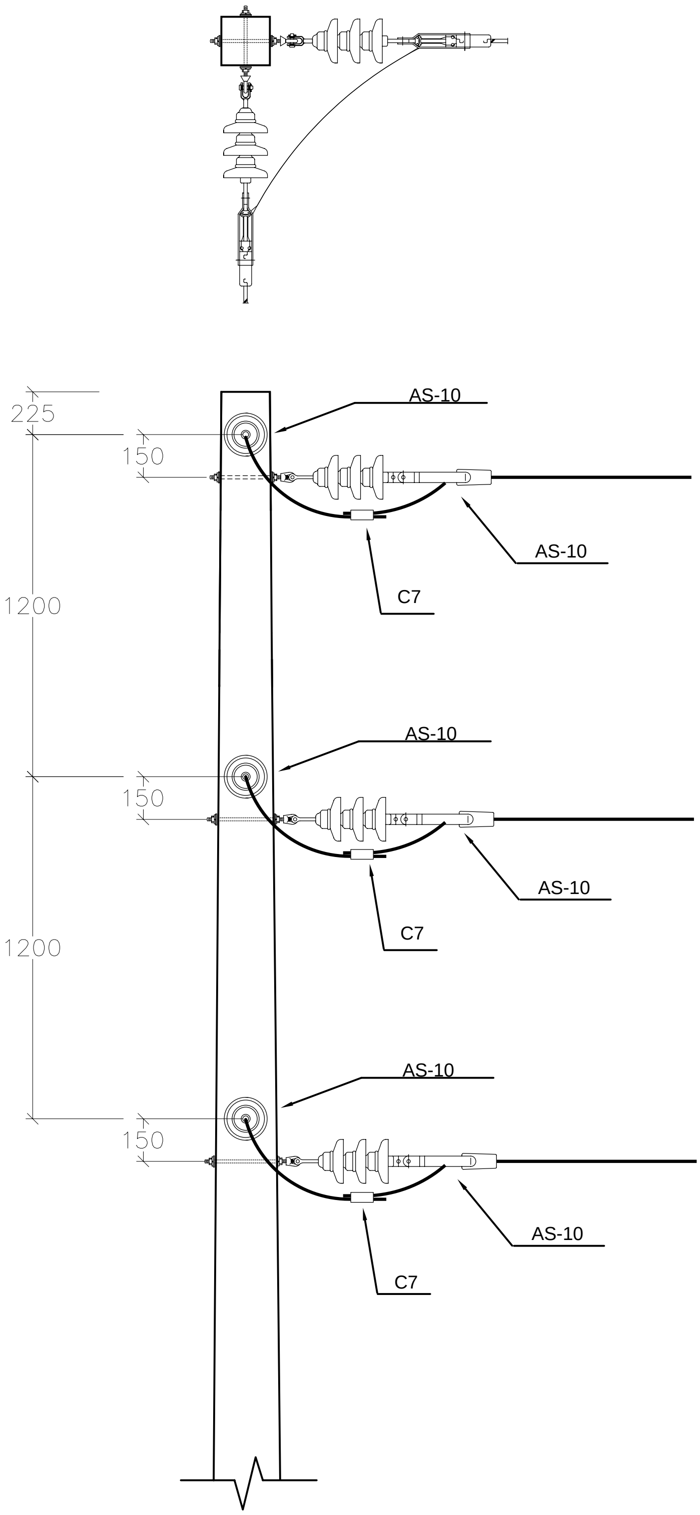
Rehabilitation and Extension of Kabul City
Distribution Network

Double support on crossarm (angle 5°-15°)
3 phase, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing:

U | MV-302C



Assembly	Qty.	Description
AS-10	6	Deadend on pole

Material	Qty.	Description
	3	Compression tap connectors, H type for ACSR, as requested

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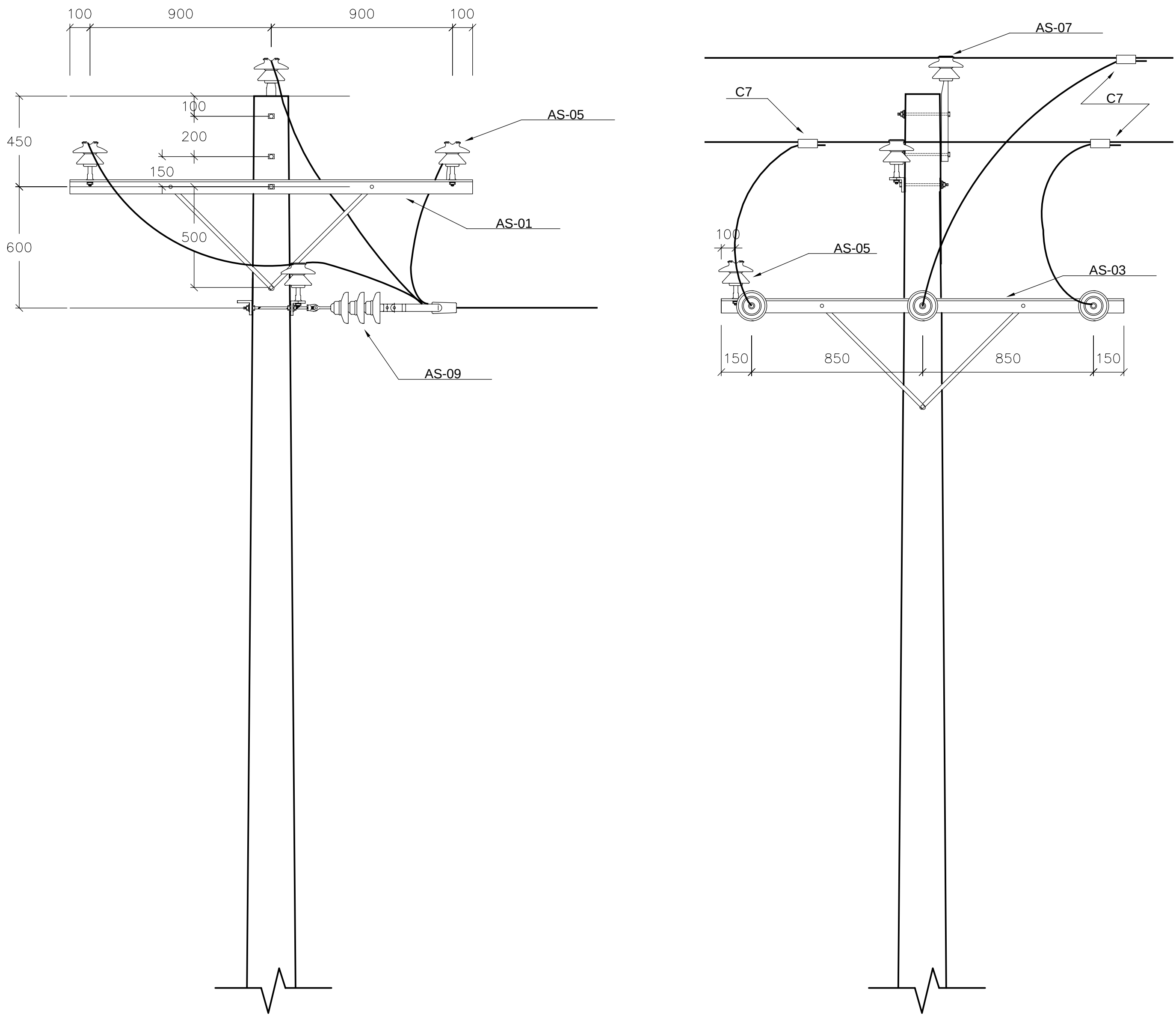
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Deadend (angle 60°-90°)
3 phase, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing: U MV-303C



Assembly	Qty.	Description
AS-01	1	Single crossarm steel (2000 mm)
AS-03	1	Double crossarm steel (2000 mm)
AS-05	3	Single support on crossarm (tangent)
AS-07	1	Single support on top pole
AS-09	3	Deadend on crossarm

Material	Qty.	Description
	3	Preformed distribution ties for ACSR
C7	3	Compression tap connectors, H type for ACSR, as requested

Ministry of Water and Power
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MWP

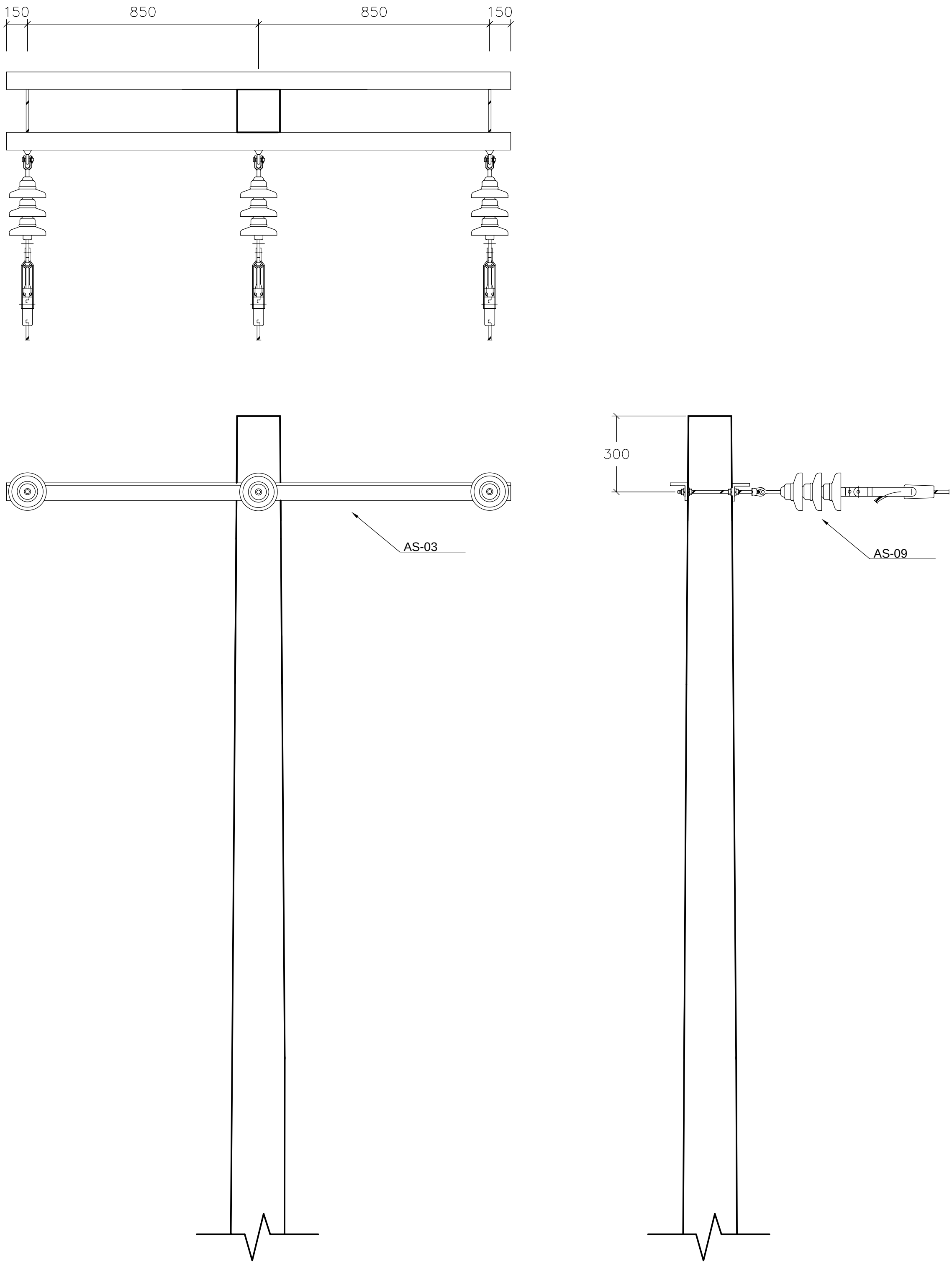
Rehabilitation and Extension of Kabul City
Distribution Network

Single support on crossarm with tap guide
3 phase, MV

Drawing:

Date: March, 2005 | Revision: 2 | Scale: Without

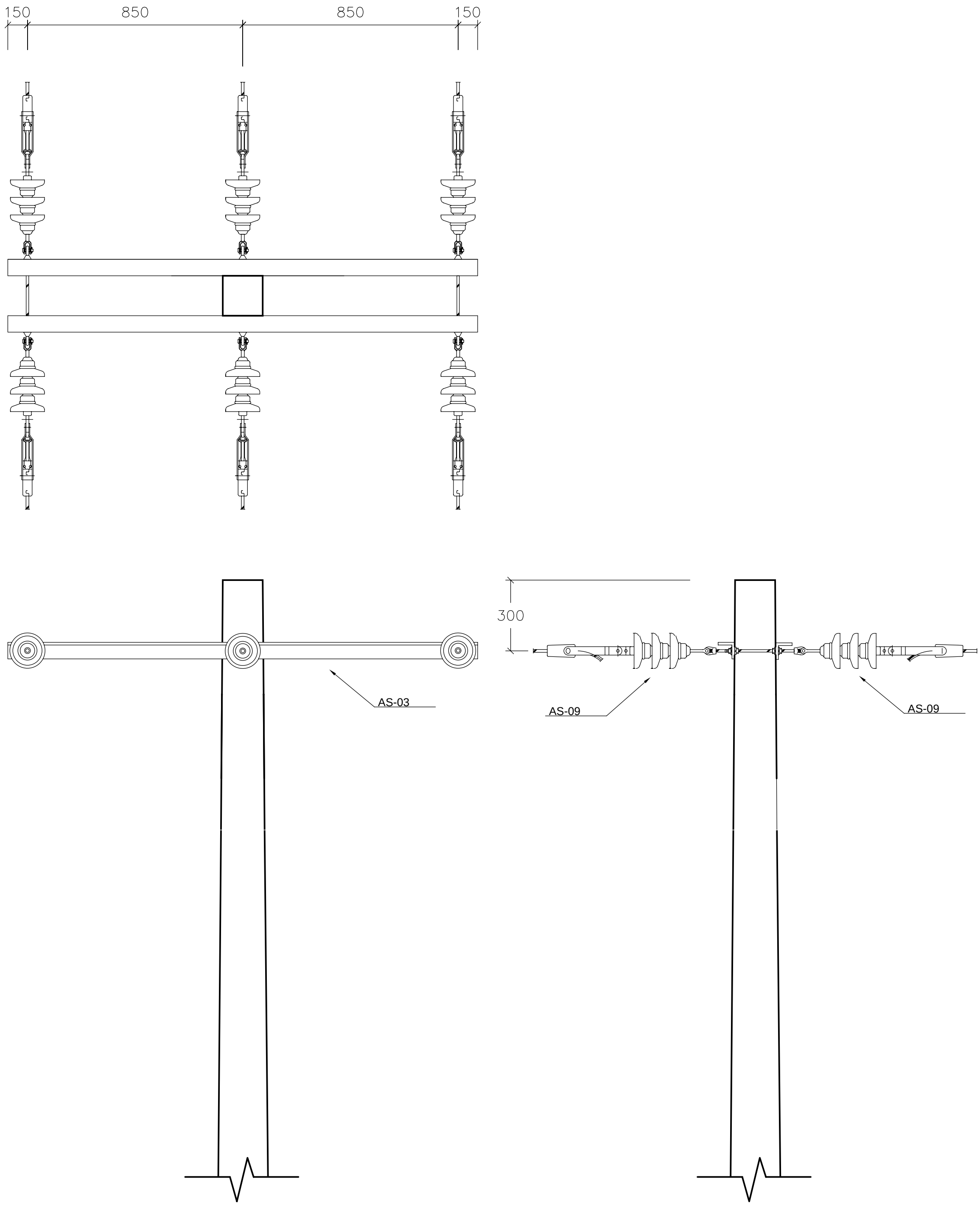
U | MV-304C



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-09	3	Deadend on crossarm

Material	Qty.	Description

Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single deadend on crossarm 3 phase, MV			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: March, 2005	Revision: 2	Scale: Without	U **MV-305C**



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-09	6	Deadend on crossarm

Material	Qty.	Description

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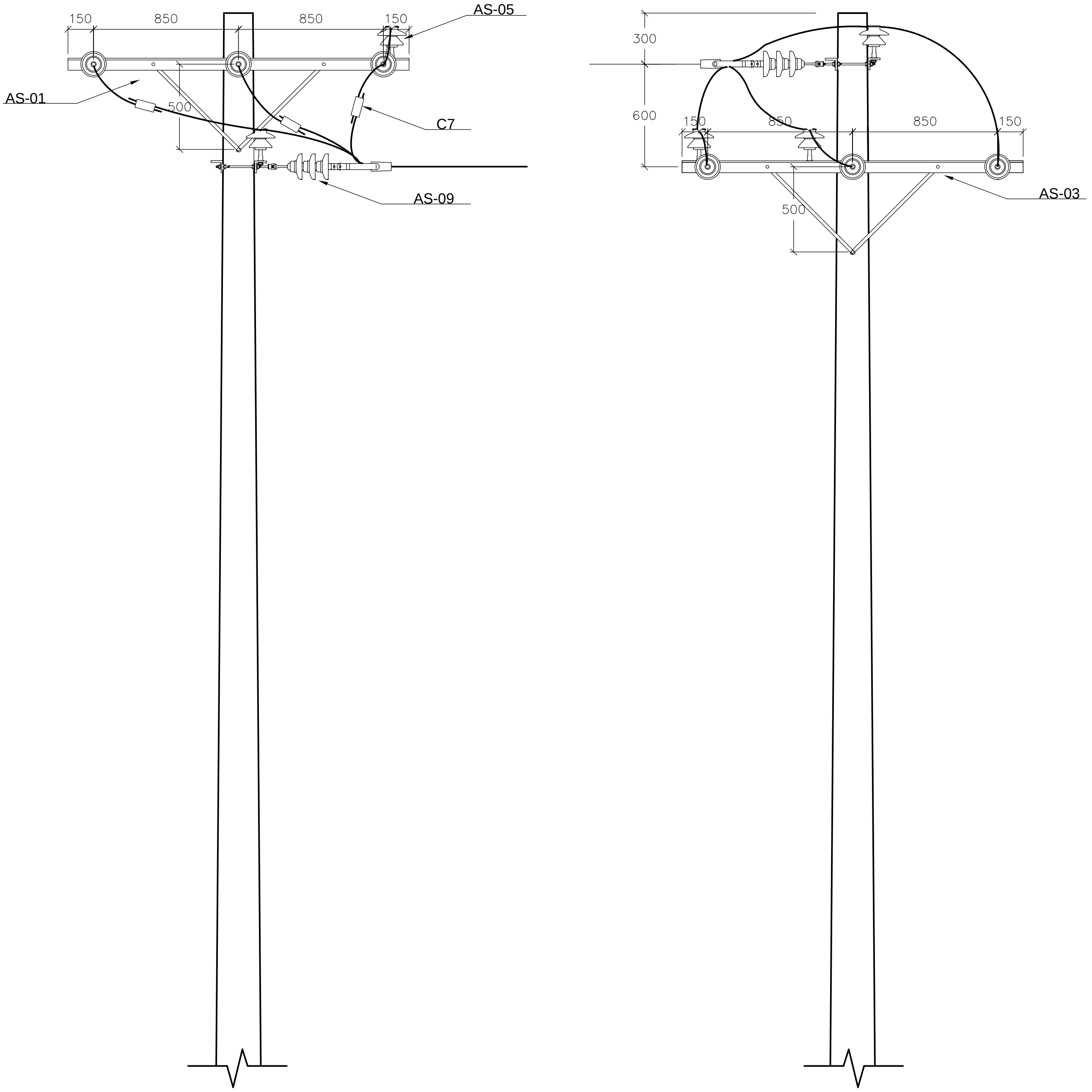
Rehabilitation and Extension of Kabul City Distribution Network

Double deadend on crossarm
3 phase, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing:

U **MV-306C**



Assembly	Qty.	Description
AS-01	1	Single crossarm steel (2000 mm)
AS-03	1	Double crossarm steel (2000 mm)
AS-05	3	Single support on crossarm (tangent)
AS-09	6	Deadend on crossarm

Material	Qty.	Description
	3	Preformed distribution ties for ACSR
C7	3	Compression tap connectors, H type for ACSR, as requested

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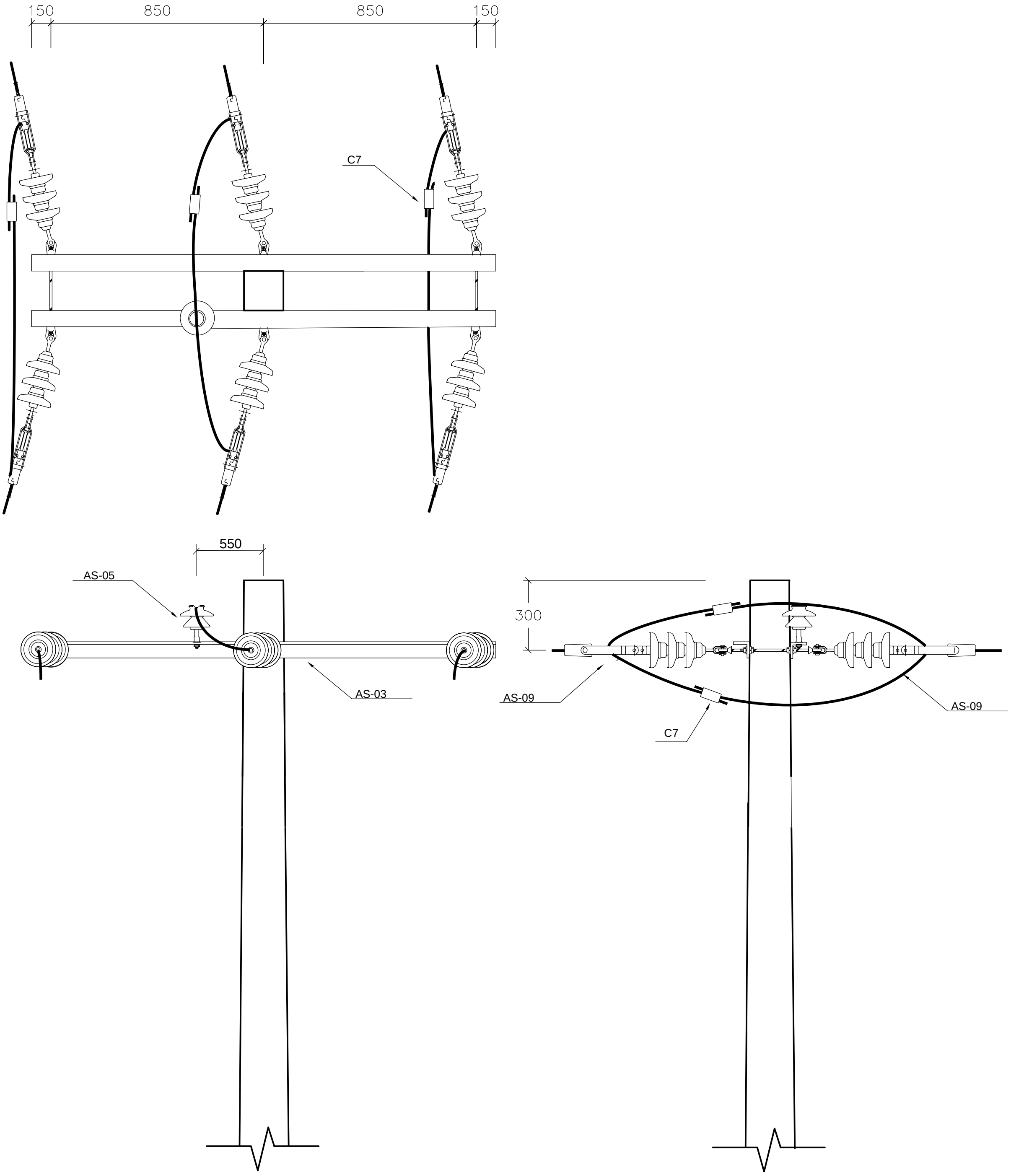
Rehabilitation and Extension of Kabul City Distribution Network

Deadend on crossarm (angle 60°-90°)
3 phase, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing: U MV-307C



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-05	1	Single support on crossarm (tangent)
AS-09	6	Deadend on crossarm

Material	Qty.	Description
	1	Preformed distribution ties for ACSR
C7	3	Compression tap connectors, H type for ACSR, as requested

Ministry of Water and Power

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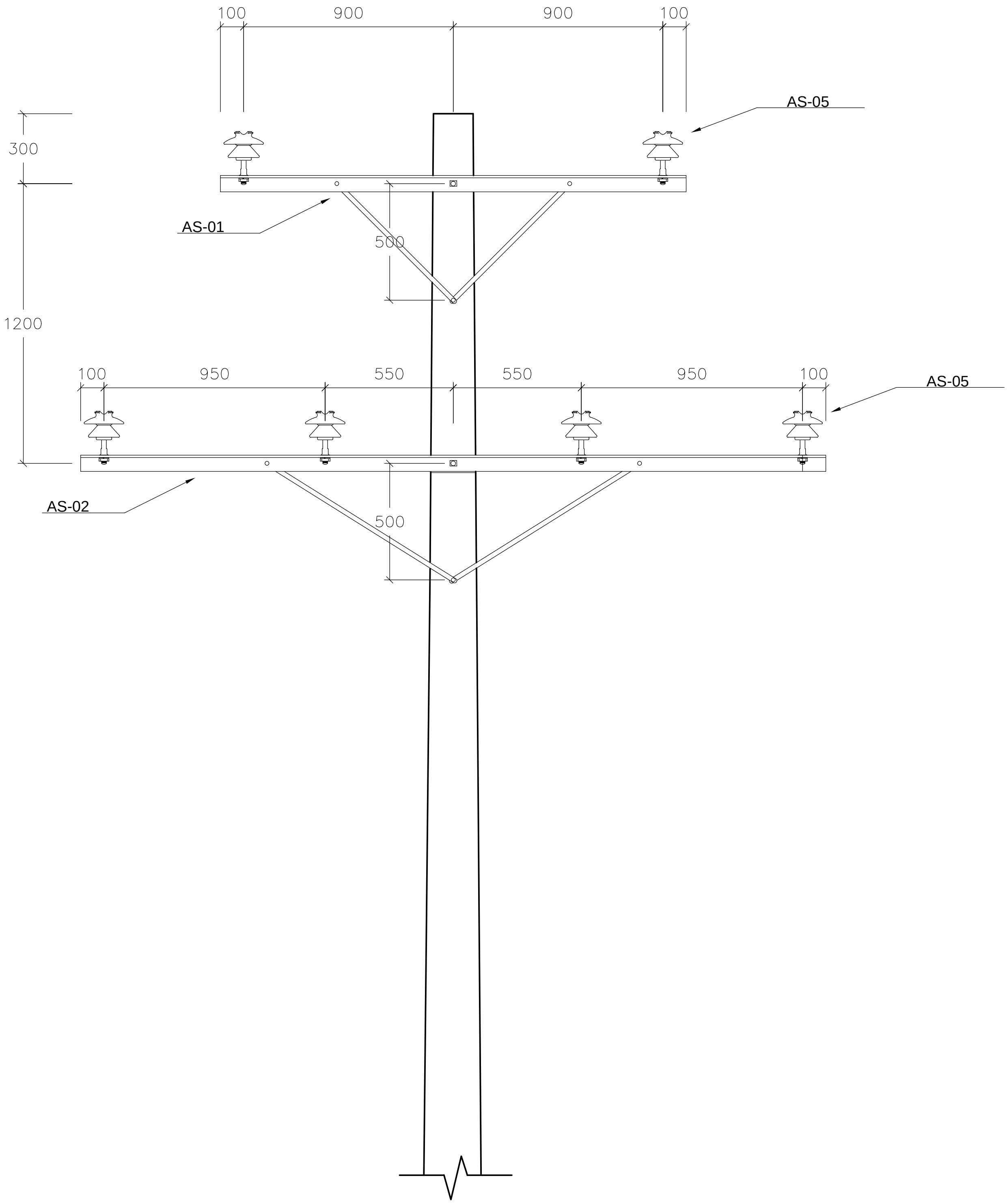
Rehabilitation and Extension of Kabul City Distribution Network

Deadend on crossarm (angle 15º- 60º)
3 phase, MV

Drawing:

U MV-308C

Date: March, 2005 | Revision: 0 | Scale: Without



Assembly	Qty.	Description
AS-01	1	Single crossarm steel (2000 mm)
AS-02	1	Single crossarm steel (3200 mm)
AS-05	6	Single support on crossarm (tangent)

Material	Qty.	Description
	6	Preformed distribution ties for ACSR

Ministry of Water and Power

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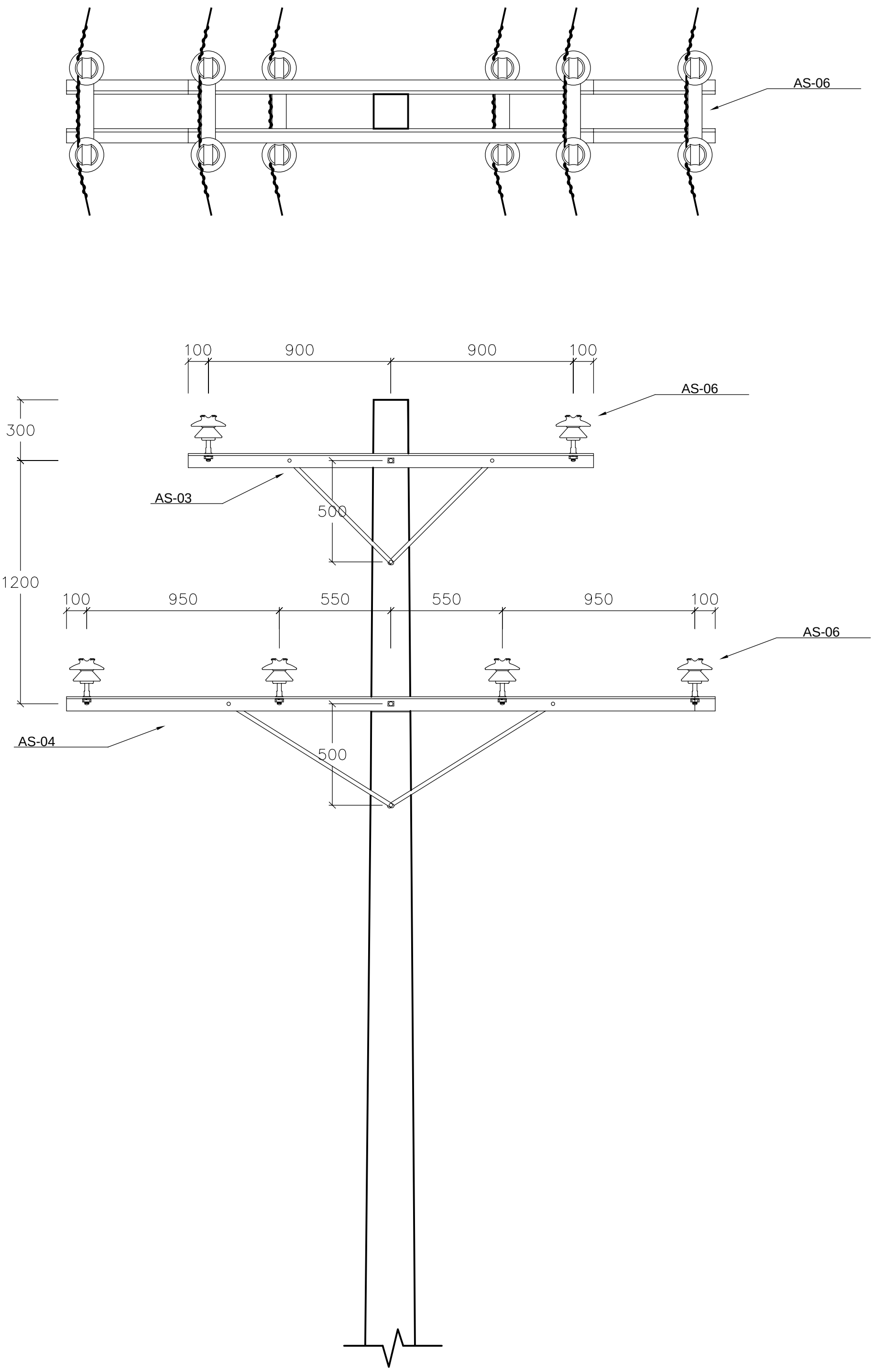
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Single support on crossarm double circuit, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing: U **MV-601C**



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-04	1	Double crossarm steel (3200 mm)
AS-06	6	Double support on crossarm (angle)

Material	Qty.	Description
	12	Preformed distribution ties for ACSR

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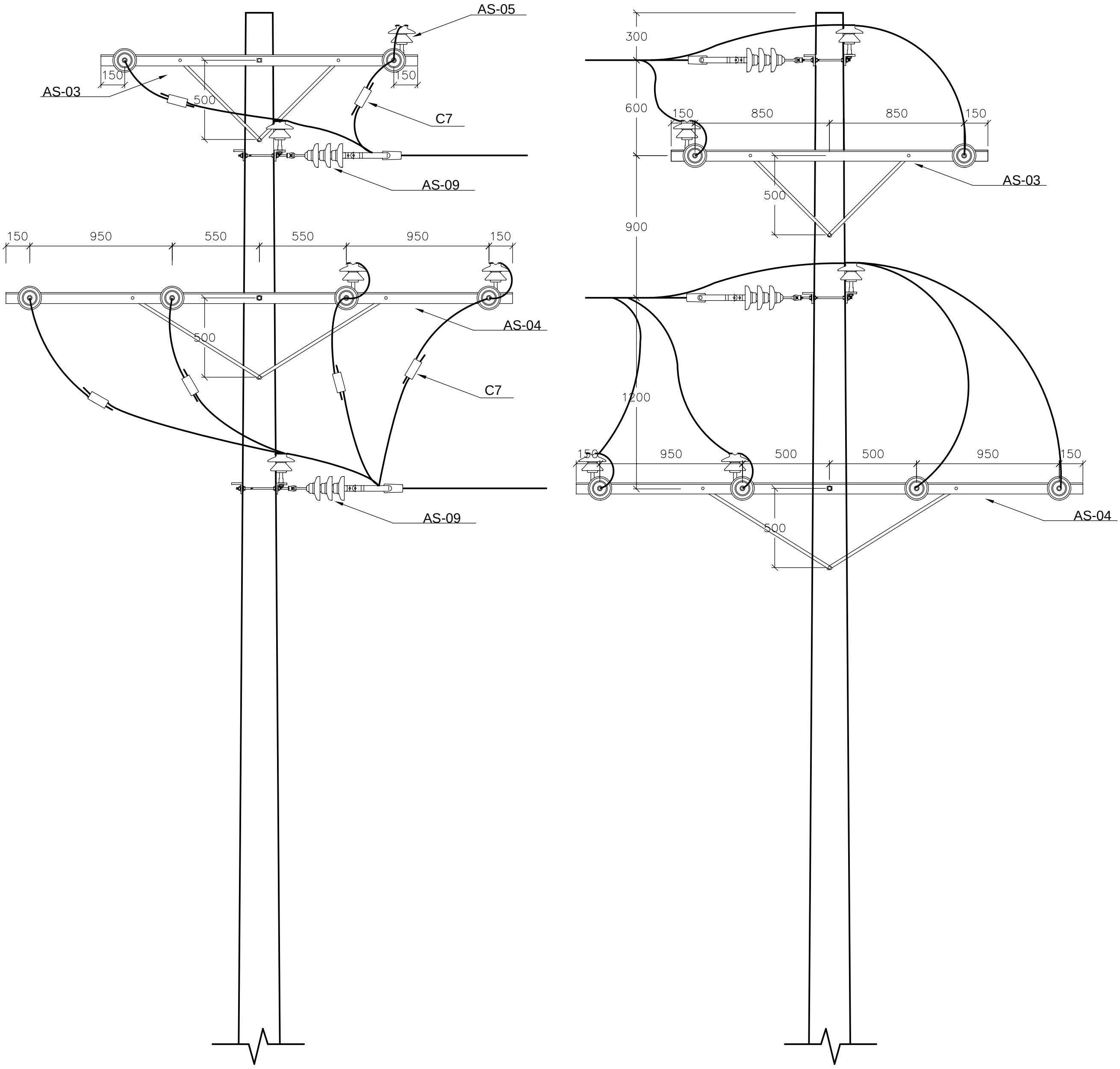
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Double support on crossarm (angle 5°-15°) double circuit, MV

Drawing: U MV-602C

Date: March, 2005 | Revision: 2 | Scale: Without



Assembly	Qty.	Description
AS-03	2	Double crossarm steel (2000 mm)
AS-04	2	Double crossarm steel (3200 mm)
AS-05	6	Single support on crossarm (tangent)
AS-09	3	Deadend on crossarm

Material	Qty.	Description
	6	Preformed distribution ties for ACSR
C7	6	Compression tap connectors, H type for ACSR, as requested

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decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH

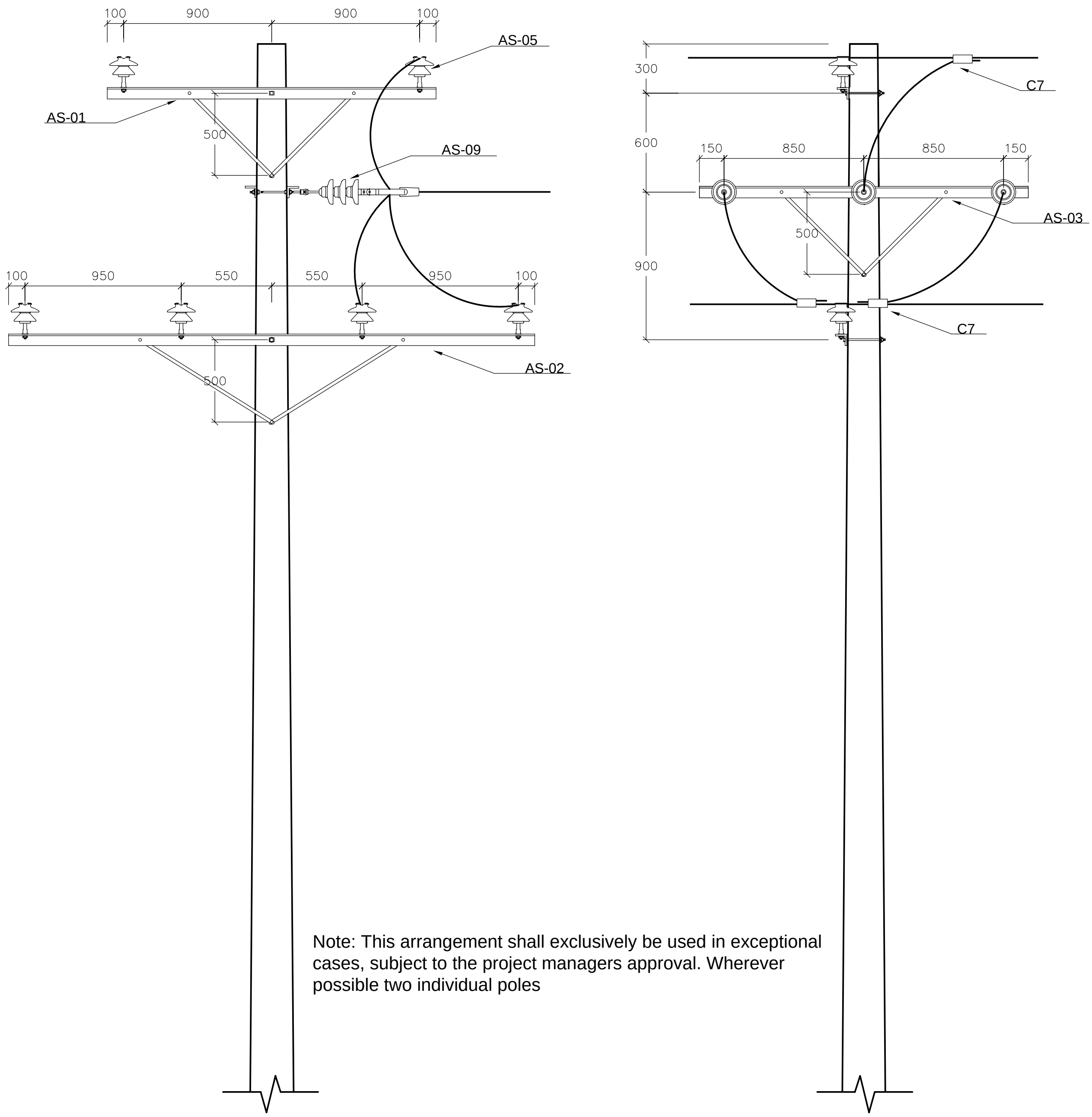
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Deadend on crossarm (angle 60°-90°) double circuit, MV

Drawing:

Date: March, 2005	Revision: 2	Scale: Without	U	MV-603C



Note: This arrangement shall exclusively be used in exceptional cases, subject to the project managers approval. Wherever possible two individual poles

Assembly	Qty.	Description
AS-01	1	Single crossarm steel (2000 mm)
AS-02	1	Single crossarm steel (3200 mm)
AS-03	1	Double crossarm steel (2000 mm)
AS-05	6	Single support on crossarm (tangent)
AS-09	3	Deadend on crossarm

Material	Qty.	Description
	6	Preformed distribution ties for ACSR
C7	3	Compression tap connectors, H type for ACSR, as requested

Ministry of Water and Power

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MWP

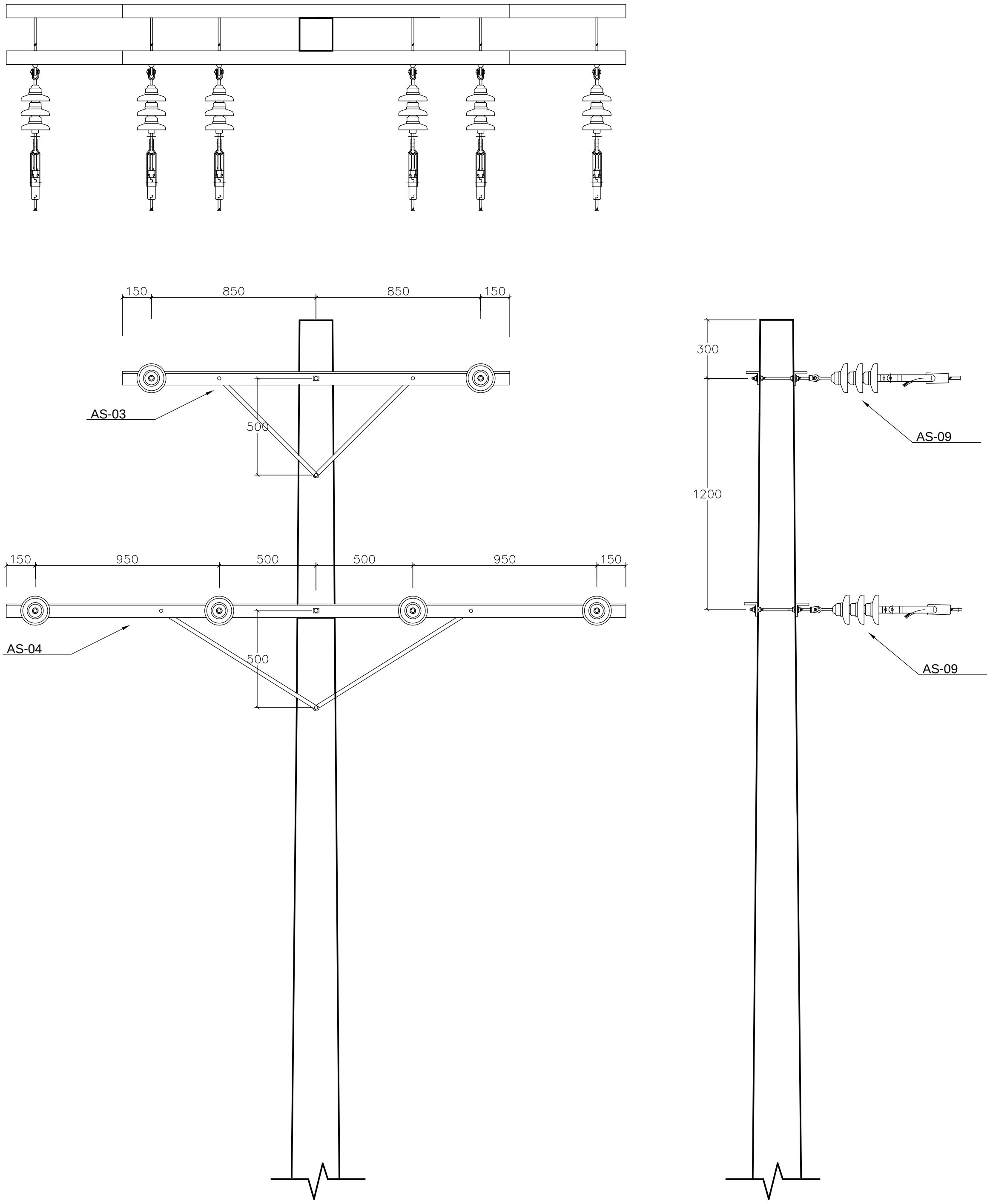
Rehabilitation and Extension of Kabul City Distribution Network

Single support on crossarm with tap guide double circuit, MV

Drawing:

U MV-604C

Date: March, 2005 | Revision: 2 | Scale: Without



Assembly	Qty.	Description	Material	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)			
AS-04	1	Double crossarm steel (3200 mm)			
AS-09	6	Deadend on crossarm			

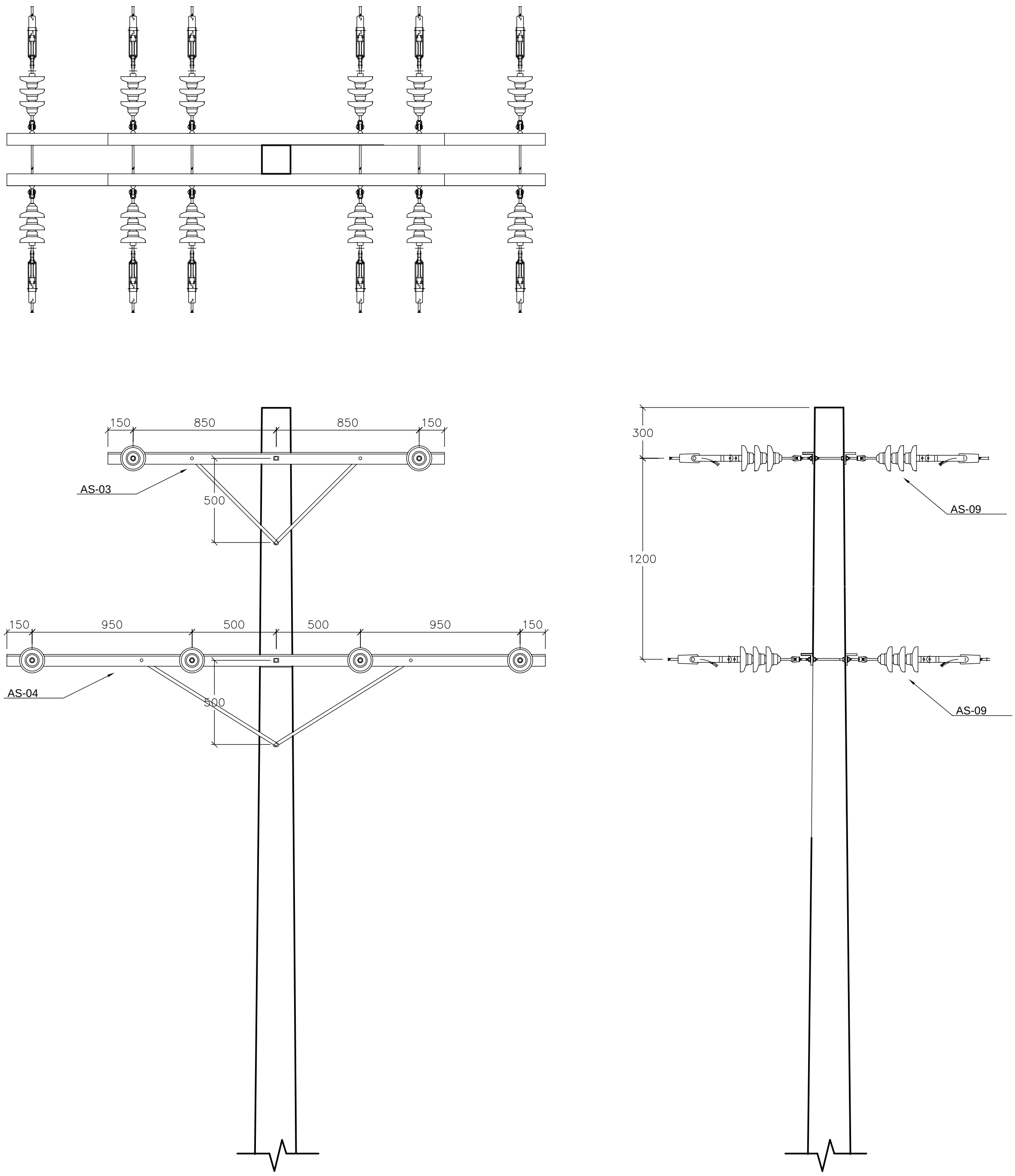
Ministry of Water and Power
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Single deadend on crossarm double circuit, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing: U MV-605C



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-04	1	Double crossarm steel (3200 mm)
AS-09	12	Deadend on crossarm

Material	Qty.	Description

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MWP

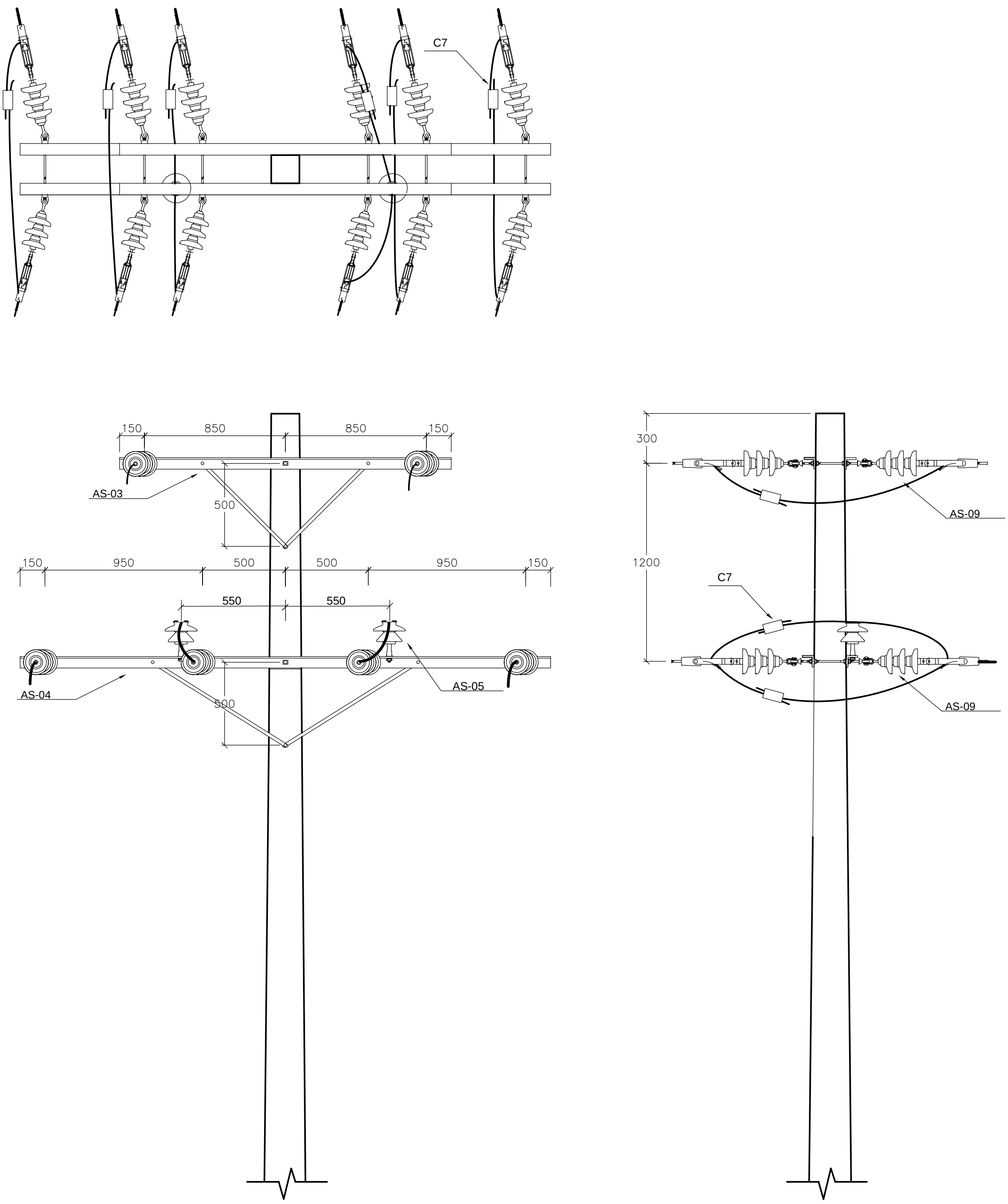
Rehabilitation and Extension of Kabul City Distribution Network

Double deadend on crossarm
double circuit, MV

Date: March, 2005 | Revision: 2 | Scale: Without

Drawing:

U **MV-606C**



Assembly	Qty.	Description
AS-03	1	Double crossarm steel (2000 mm)
AS-04	1	Double crossarm steel (3200 mm)
AS-05	2	Single support on crossarm (tangent)
AS-09	6	Deadend on crossarm

Material	Qty.	Description
	2	Preformed distribution ties for ACSR
C7	6	Compression tap connectors, H type for ACSR, as requested

Ministry of Water and Power
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH

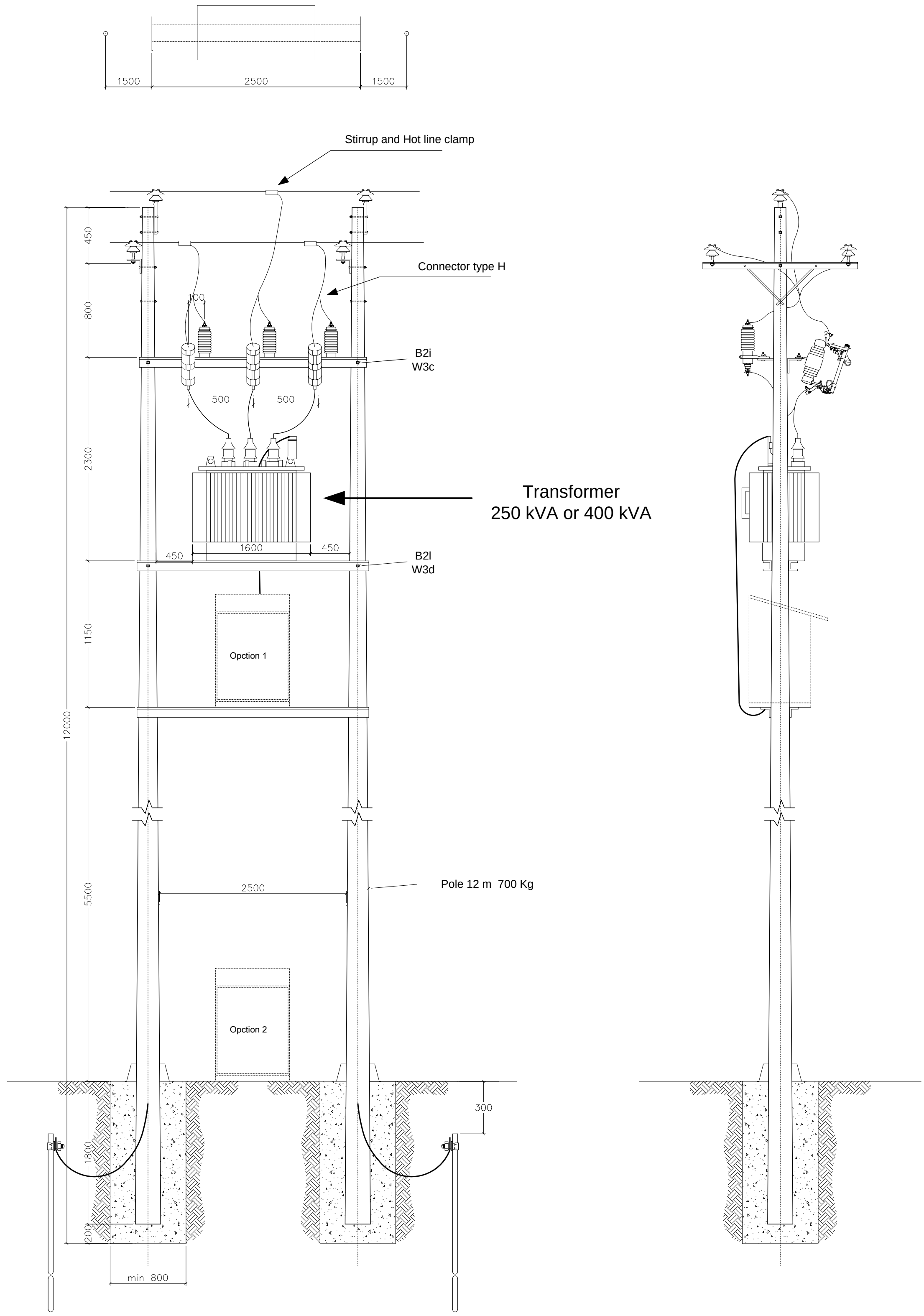
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Deadend on crossarm (angle 15º- 60º) double circuit, MV

Date: January, 2005 | Revision: 1 | Scale: Without

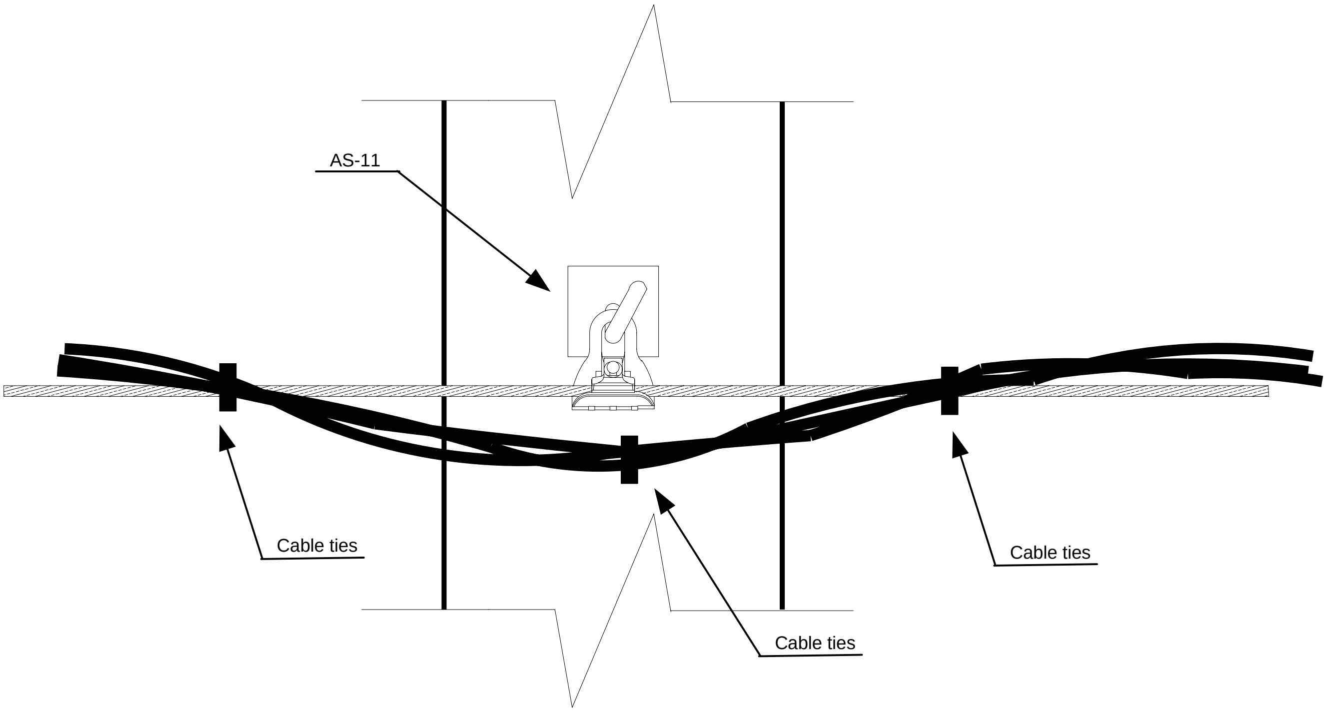
Drawing: U MV-607C



Nota:
Option 1: For LV Overhead Line Installations
Option 2: For LV Underground Installations

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Pole Mounted Transformer	DRAWING No.
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005 / Revision: 2 / Scale: Without	U T - 01

LV-101	**SINGLE SUPPORT ANGLE (0°- 30°)**
LV-102	**DOUBLE DEADEND**
LV-103	**SINGLE SUPPORT WITH DEADEND BRANCH**
LV-104	**DOUBLE DEADEND WITH DEADEND BRANCH**
LV-105	**DOUBLE SUPPORT (angle 30° - 60º)**
LV-106	**DOUBLE DEADEND (angle 60º - 90º)**
LV-107	**SINGLE DEADEND**



Assembly	Qty.	Description
AS-11	1	Single support

Material	Qty.	Description
	3	Cable ties, self locking (black)

Ministry of Energy and Water
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Rehabilitation and extension of the Kabul City distrubution Network

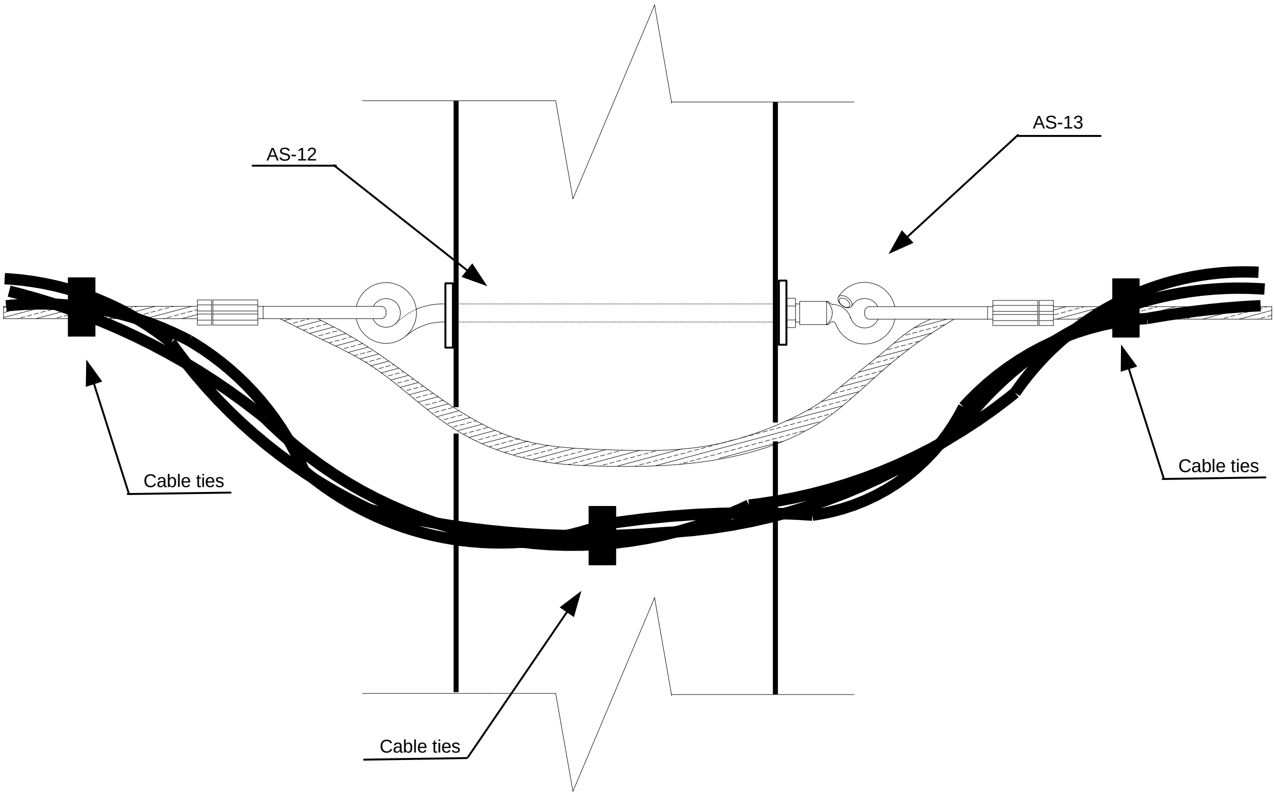
Low Voltage Construction

Single Support
(angle 0° - 30°)

Date: March, 2005	Revision: 2	Scale: Without

DRAWING No.

U LV - 101



Assembly	Qty.	Description
AS-12	1	Single deadend
AS-13	1	Single deadend (existing spiral hook)

Material	Qty.	Description
	3	Cable ties, self locking (black)

Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP

Rehabilitation and extension of the Kabul City distrubution Network

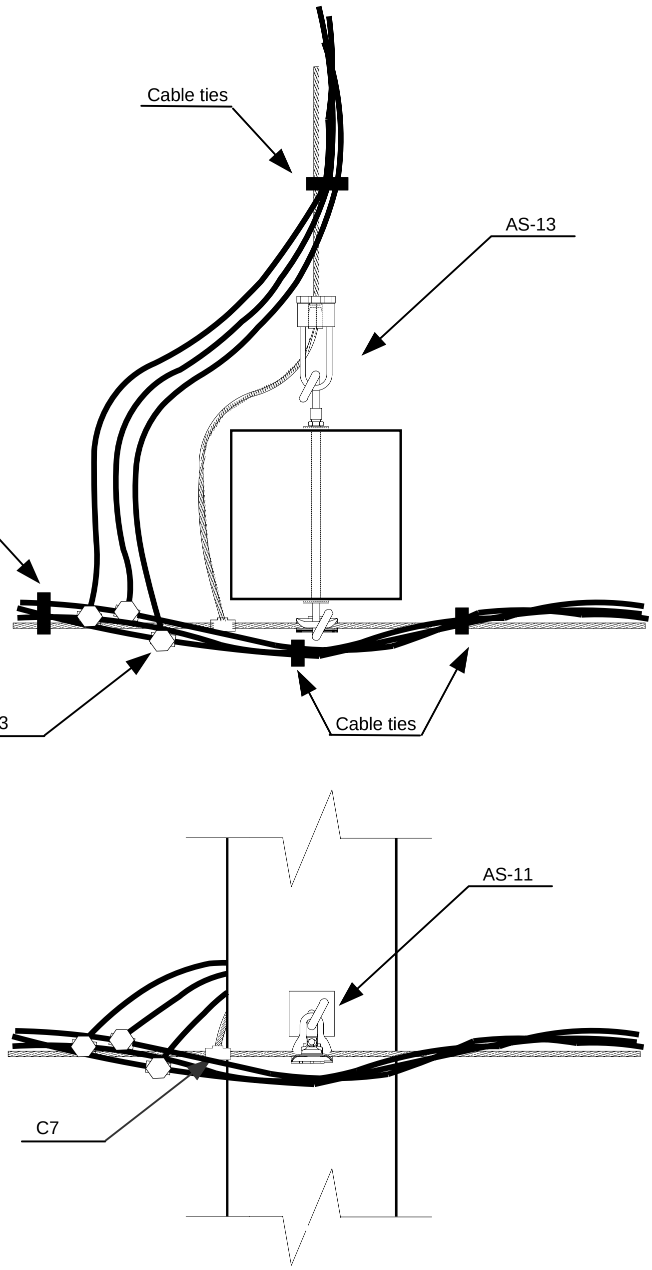
Low Voltage Construction

Double Deadend

Date: March, 2005 | Revision: 2 | Scale: Without

DRAWING No.

U LV - 102



Assembly	Qty.	Description
AS-11	1	Single support
AS-13	1	Single deadend (existing spiral hook)

Material	Qty.	Description
	4	Cable ties, self locking (black)
C7	1	Compression tap connectors, H type for AAAC, as requested
C13	3	Insulation piercing connectors, as requested

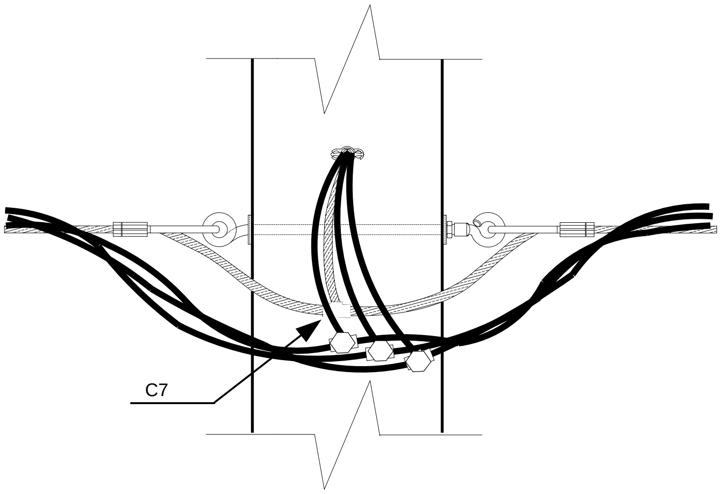
Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP

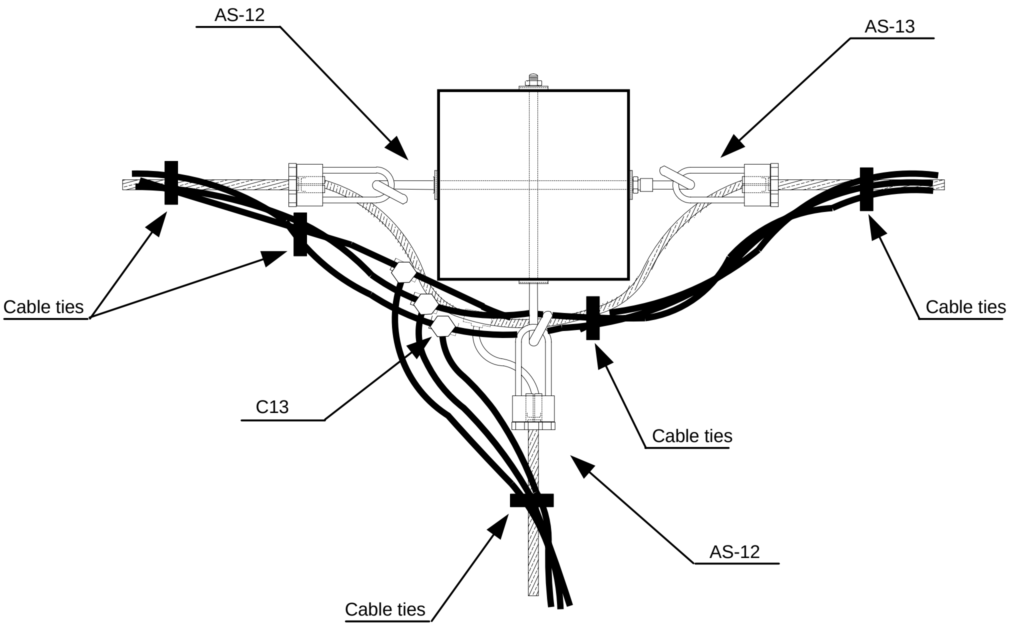
Rehabilitation and extension of the Kabul City distrubution Network

Low Voltage Costruction
Single Suport with Deadend Branch

Date: March, 2005 | Revision: 2 | Scale: Without

DRAWING No.
U LV - 103





Assembly	Qty.	Description
AS-12	2	Single deadend
AS-13	1	Single deadend (existing spiral hook)

Material	Qty.	Description
	5	Cable ties, self locking (black)
C7	1	Compression tap connectors, H type for AAAC, as requested
C13	3	Insulation piercing connectors, as requested

Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP

Rehabilitation and extension of the Kabul City distrubution Network

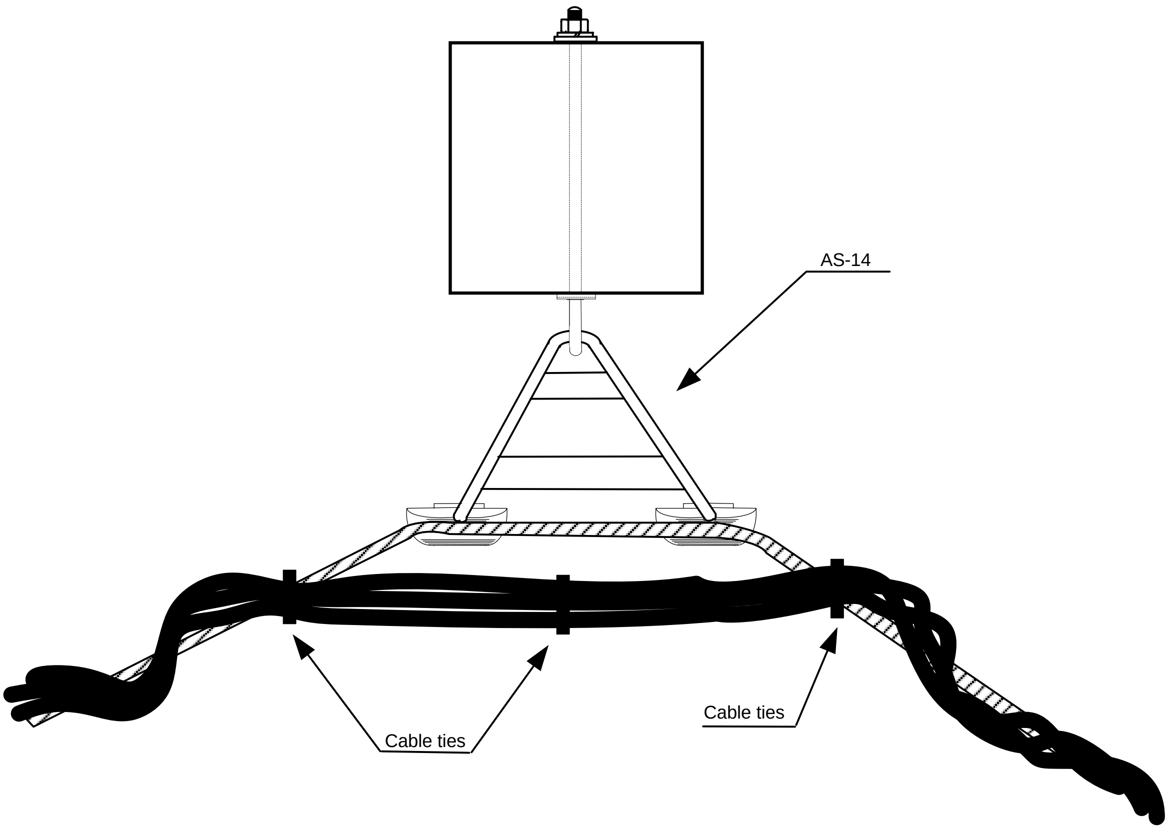
Low Voltage Construction

Double Deadend with Deadend Branch

Date: March, 2005 | Revision: 2 | Scale: Without

DRAWING No.

U LV - 104



Assembly	Qty.	Description
AS-14	1	Double support (angle up to 60º)

Material	Qty.	Description
	3	Cable ties, self locking (black)

Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP

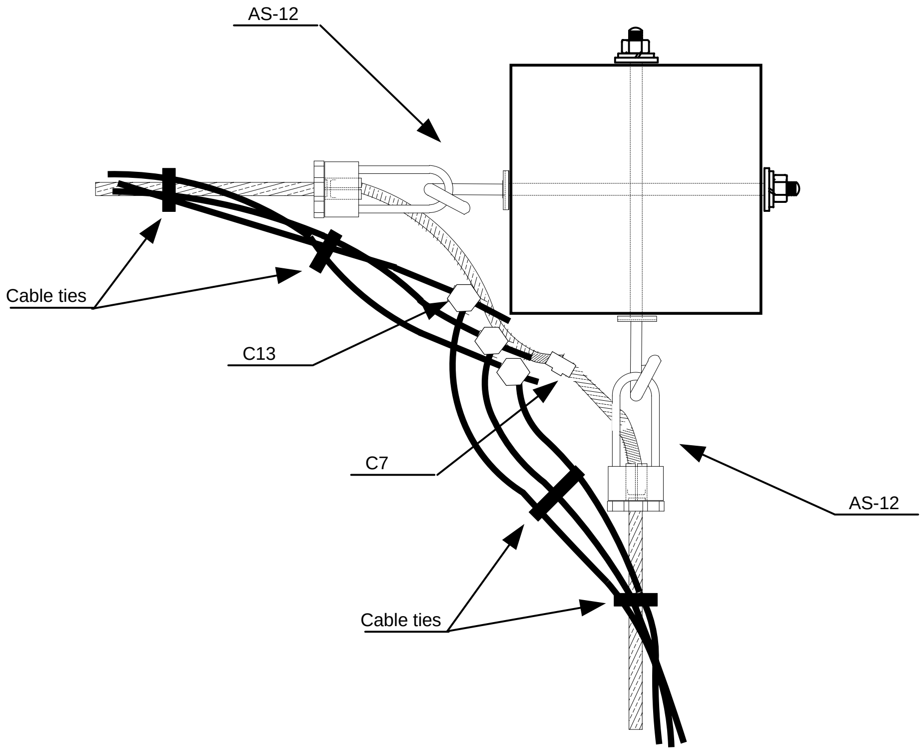
Rehabilitation and extension of the Kabul City distrubution Network

Low Voltage Construction
Double support (angle up to 60º)

Date: March, 2005	Revision: 0	Scale: Without

DRAWING No.

U LV - 105



Assembly	Qty.	Description
AS-12	2	Single deadend

Material	Qty.	Description
	4	Cable ties, self locking (black)
C7	1	Compression tap connectors, H type for AAAC, as requested
C13	3	Insulation piercing connectors, as requested

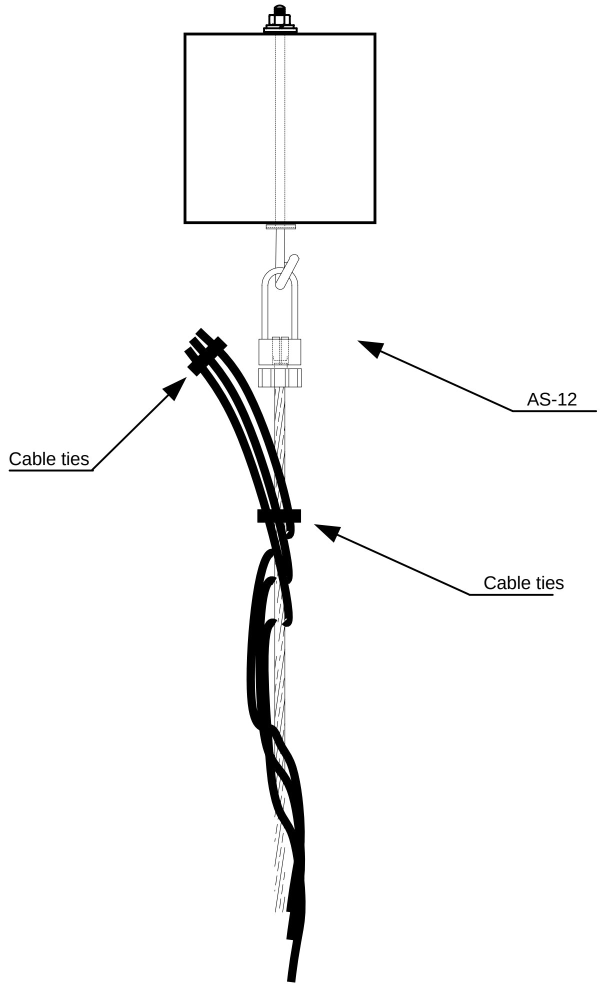
Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH

Rehabilitation and extension of the Kabul City distrubution Network

Low Voltage Construction
Double Deadend (angle 60º-90º)

Date: March, 2005 | Revision: 0 | Scale: Without

DRAWING No.
U LV - 106



Assembly	Qty.	Description
AS-12	1	Single deadend

Material	Qty.	Description
	2	Cable ties, self locking (black)

Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH

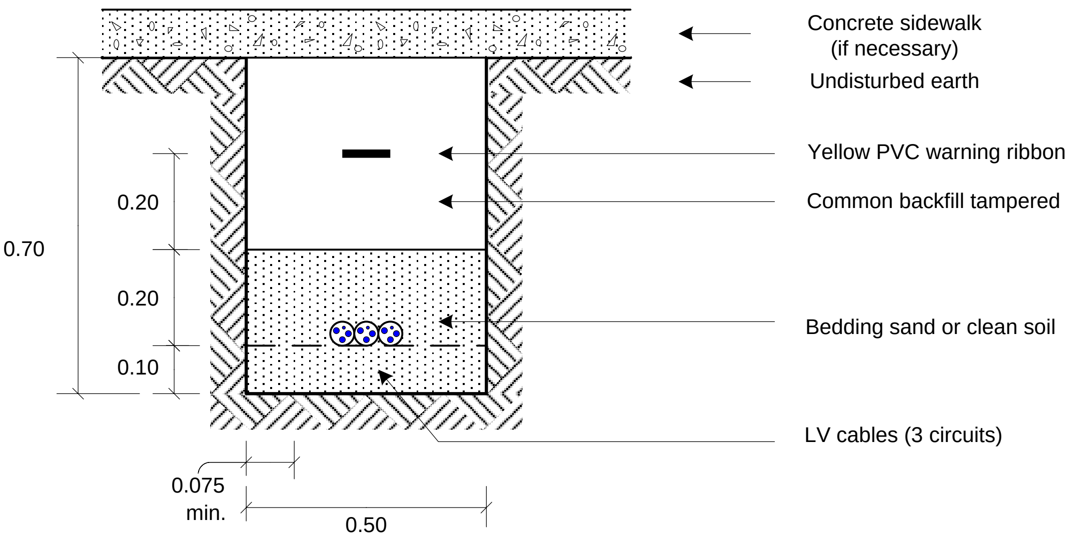
Rehabilitation and extension of the Kabul City distrubution Network

Low Voltage Construction
Single Deadend

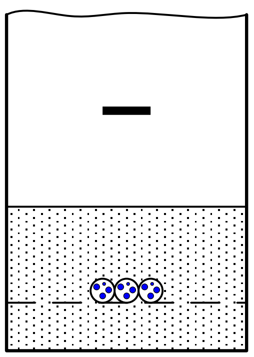
Date: March, 2005 | Revision: 0 | Scale: Without

DRAWING No.
U LV - 107

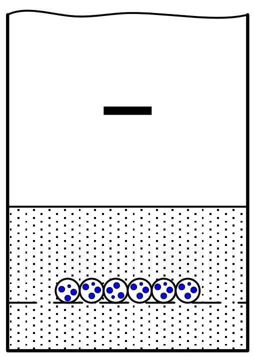
T-001	TRENCHES FOR DIRECT BURIAL CABLES – Low Voltage
T-002	TRENCHES FOR DIRECT BURIAL CABLES – Medium Voltage
T-003	TRENCHES FOR DIRECT BURIAL CABLES – Low and Medium Voltage
T-004	STREET CROSSING IN CONCRETE ENCASED DUCT
T-004.1	STREET CROSSING IN CONCRETE ENCASED DUCT
T-005	STREET CROSSING IN CONDUIT Special case
T-006	STREET CROSSING AND SECTIONS
T-007	TRENCHES FOR DIRECT BURIAL CABLES – Optical cable
T-009	TRENCHES FOR DIRECT BURIAL CABLES – Optical Cable and Medium Voltage



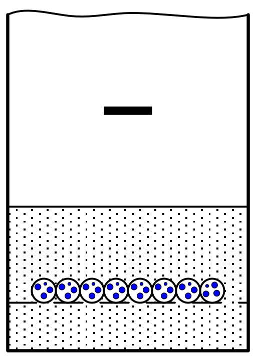
SECONDARY BASIC UNIT
T-001



SECONDARY BASIC UNIT
T-001.1
with 3 circuits



SECONDARY BASIC UNIT
T-001.2
with 6 circuits



SECONDARY BASIC UNIT
T-001.3
with 8 circuits

Depth and width as specified are minimum.
Depth specified is to finish grade.
Sand bedding is not part of this unit and will be specified as needed. Backfilling is part of all trench units.
Backfill shall be placed in uniform layers, ten centimeters thick, on both sides of the cables and thoroughly compacted with pneumatic or hand tampers.
Warning tape shall be placed above the installed cable.
Contractor shall repair any damages immediately

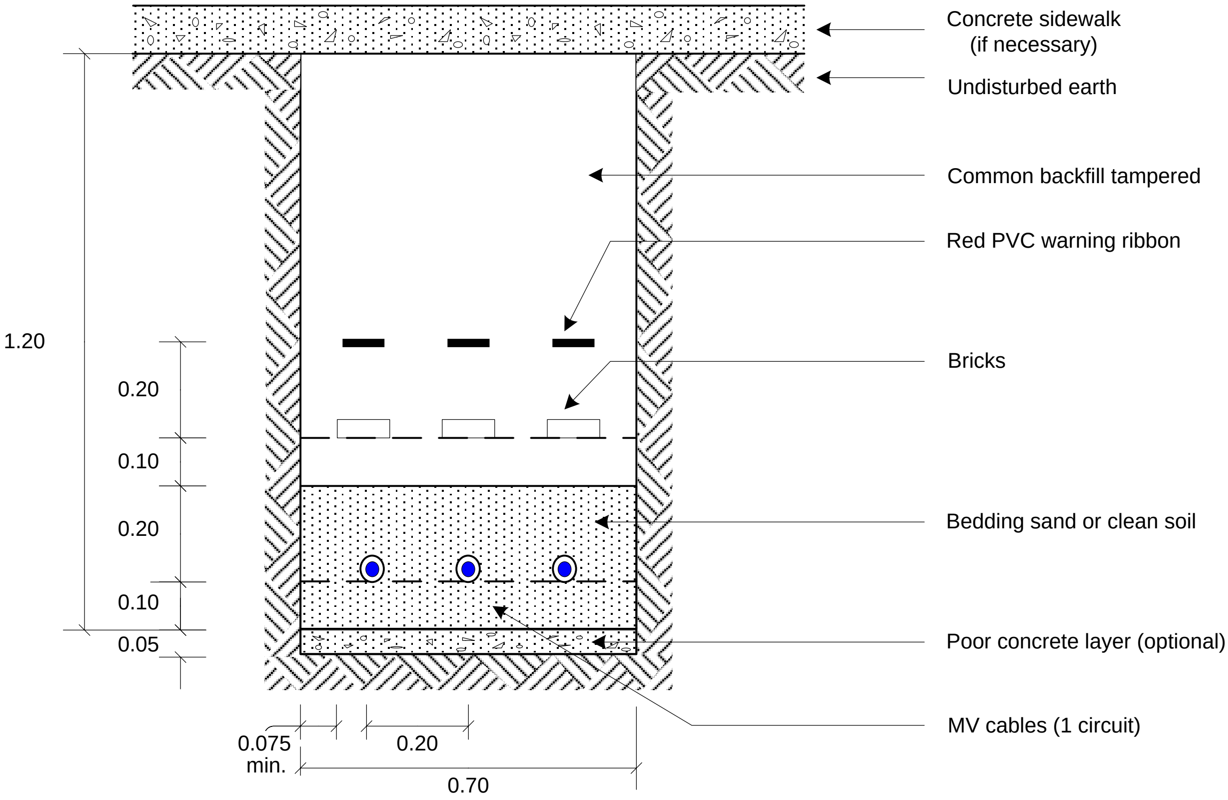
Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH
MWP

Rehabilitation and Extension of Kabul City
Distribution Network

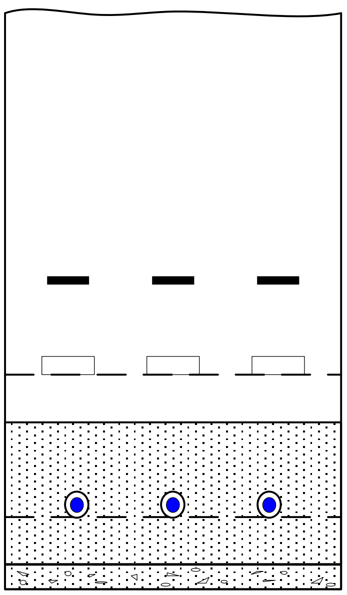
TRENCHES FOR DIRECT BURIAL
CABLES – Low Voltage

Date: October, 2004	Revision: 1.1	Scale: Without

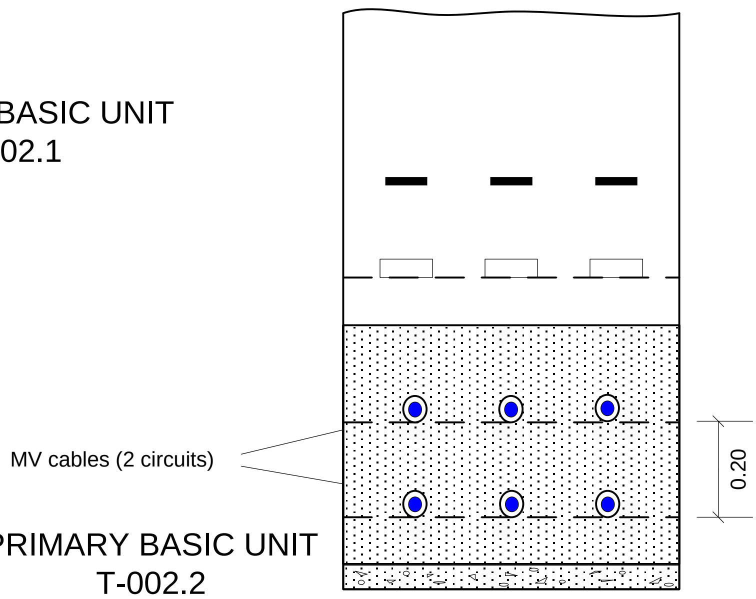
Drawing:
U **T-001**



PRIMARY BASIC UNIT
T-002



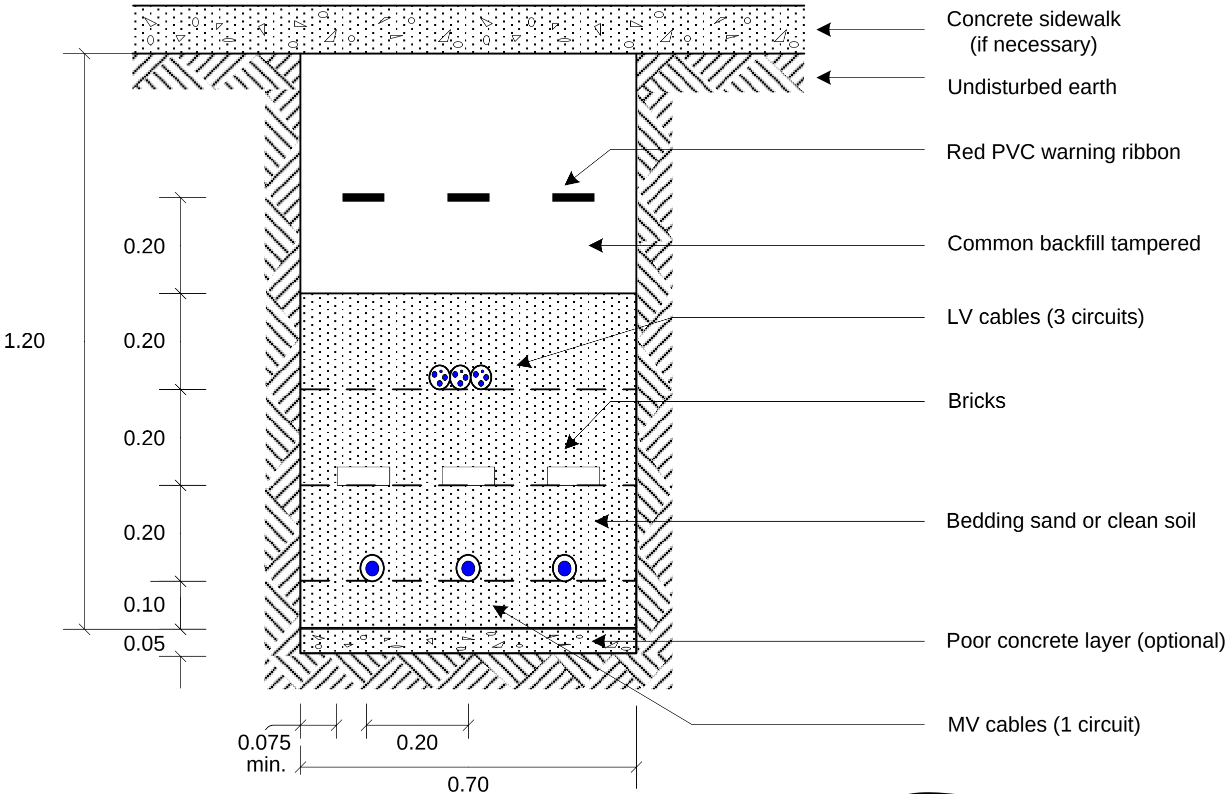
PRIMARY BASIC UNIT
T-002.1



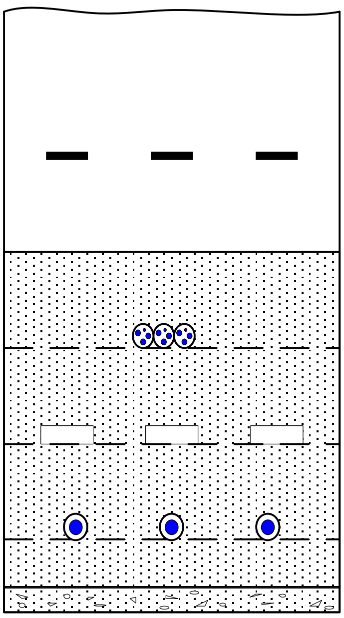
PRIMARY BASIC UNIT
T-002.2

Depth and width as specified are minimum.
Depth specified is to finish grade.
Sand bedding is not part of this unit and will be specified as needed. Backfilling is part of all trench units.
Backfill shall be placed in uniform layers, ten centimeters thick, on both sides of the cables and thoroughly compacted with pneumatic or hand tampers.
A layer of solid bricks alert future excavations about danger below. The bricks shall be put with the mayor dimensions across the cable axis.
Warning tape shall be placed above the installed cable.
Contractor shall repair any damages immediately.

Ministry of Energy and Water **decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH** MWP	TRENCHES FOR DIRECT BURIAL CABLES – Medium Voltage			Drawing:	
Rehabilitation and Extension of Kabul City Distribution Network	Date: October, 2004	Revision: 1.1	Scale: Without	**U**	**T-002**

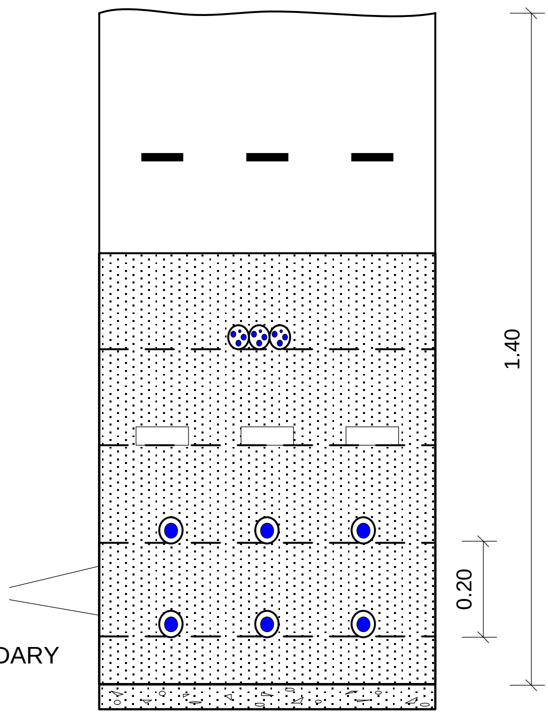


PRIMARY AND SECONDARY BASIC UNIT
T-003



PRIMARY AND SECONDARY
BASIC UNIT
T-003.1

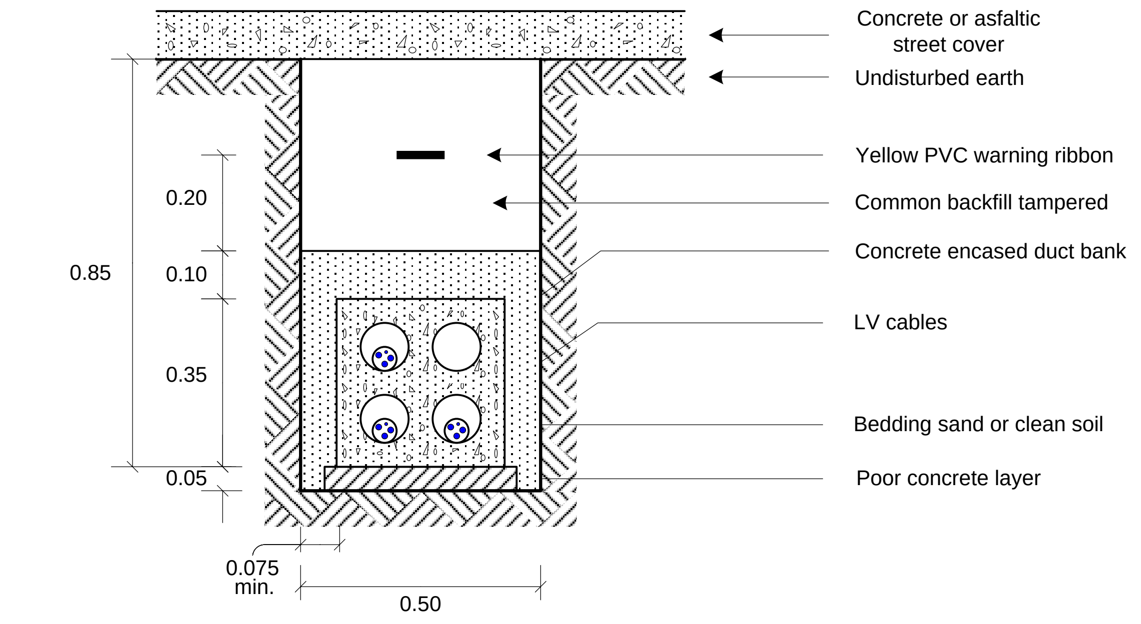
MV cables (2 circuits)



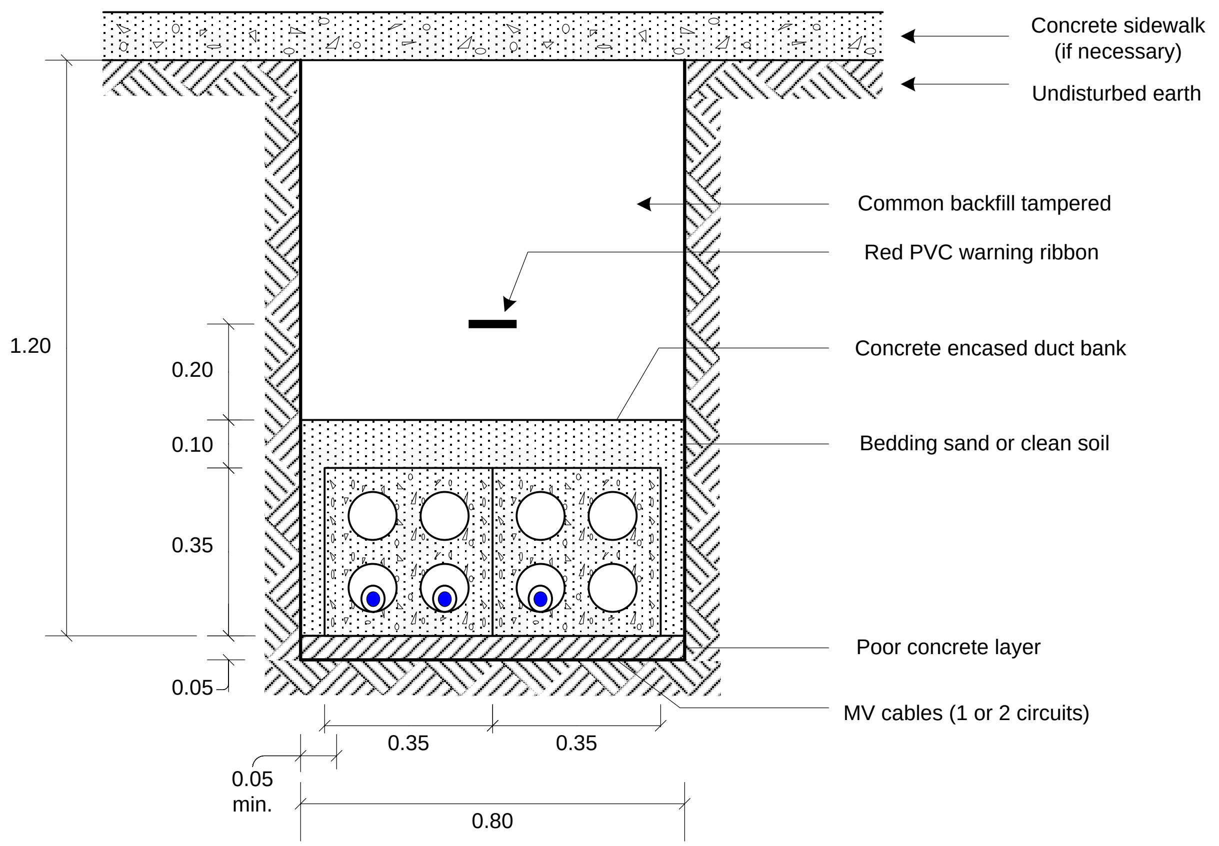
PRIMARY AND SECONDARY
BASIC UNIT
T-003.2

Depth and width as specified are minimum.
Depth specified is to finish grade.
Sand bedding is not part of this unit and will be specified as needed. Backfilling is part of all trench units.
Backfill shall be placed in uniform layers, ten centimeters thick, on both sides of the cables and thoroughly compacted with pneumatic or hand tampers.
A layer of solid bricks alert future excavations about danger below. The bricks shall be put with the mayor dimensions across the cable axis.
Warning tape shall be placed above the installed cable.
Contractor shall repair any damages immediately.

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	TRENCHES FOR DIRECT BURIAL CABLES – Low and Medium Voltage			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: October, 2004	Revision: 1.1	Scale: Without	U	T-003

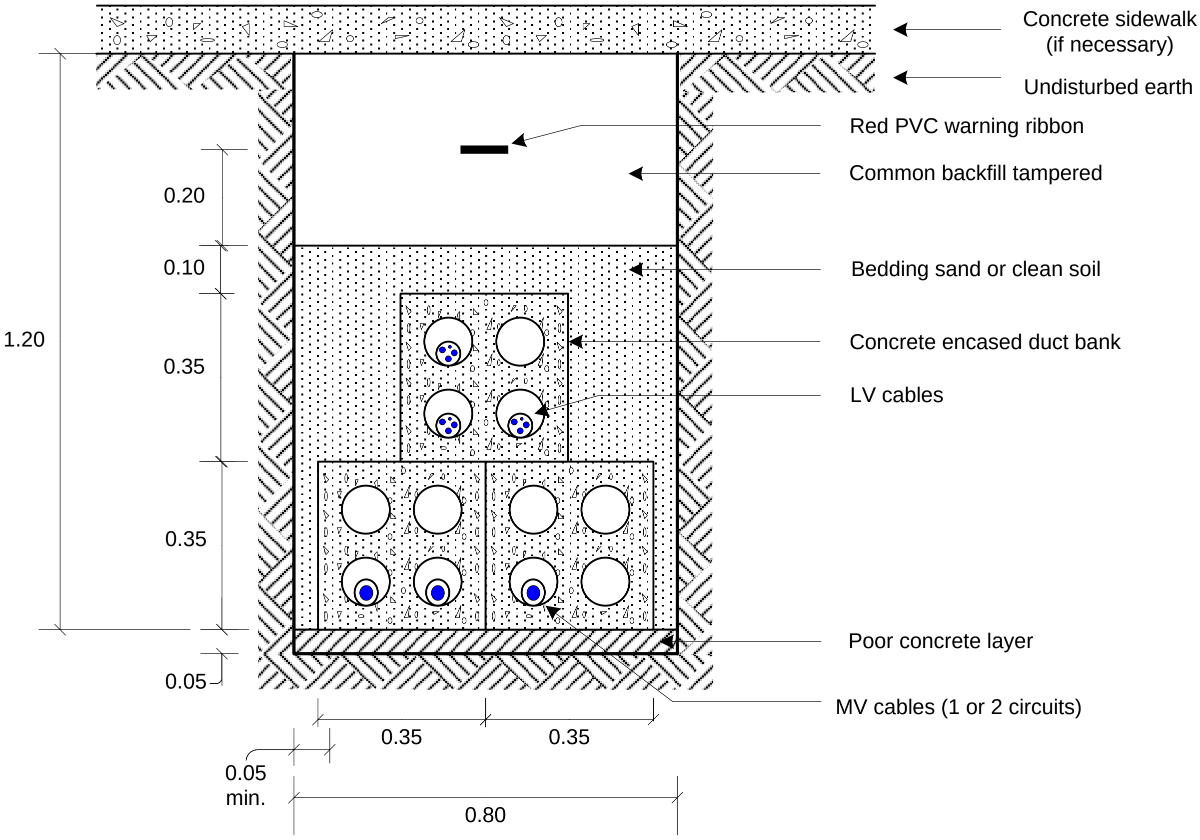


SECONDARY BASIC UNIT
T-004 a)

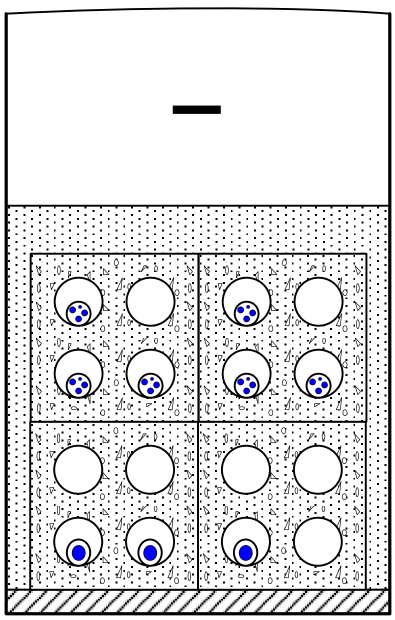


PRIMARY BASIC UNIT
T-004 b)

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	STREET CROSSING IN CONCRETE ENCASED DUCT			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: October, 2004	Revision: 1	Scale: Without	U T-004



PRIMARY and SECONDARY BASIC UNIT
T-004 c)



PRIMARY and SECONDARY BASIC UNIT
T-004 d)

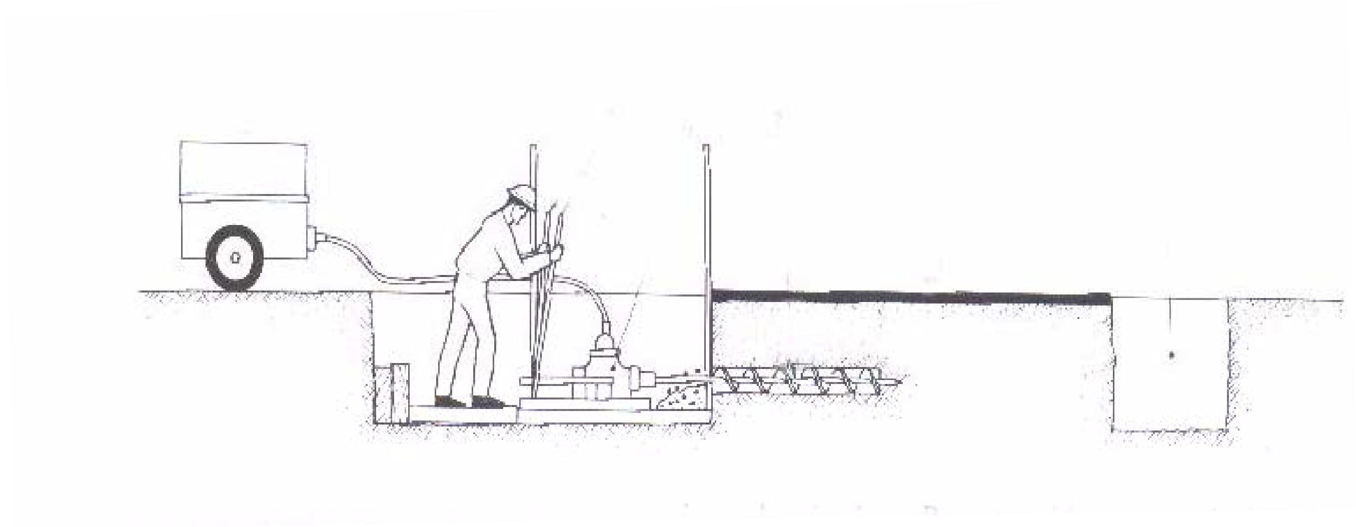
Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH
MWP

Rehabilitation and Extension of Kabul City
Distribution Network

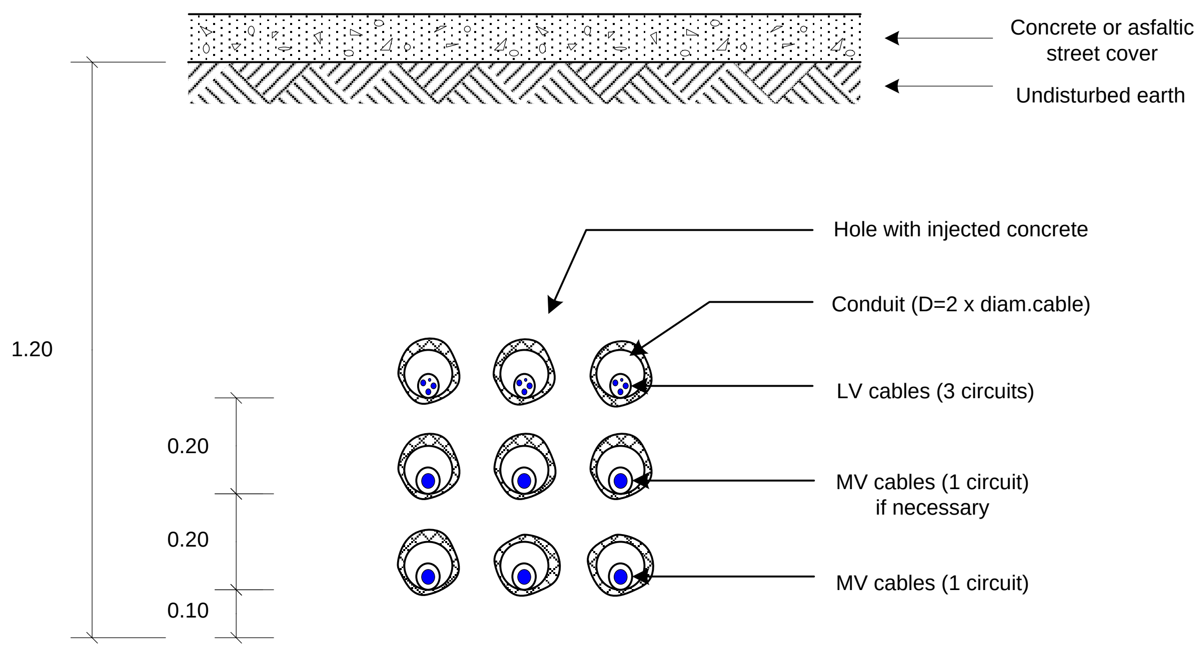
STREET CROSSING IN CONCRETE
ENCASED DUCT

Date: October, 2004 | Revision: 1 | Scale: Without

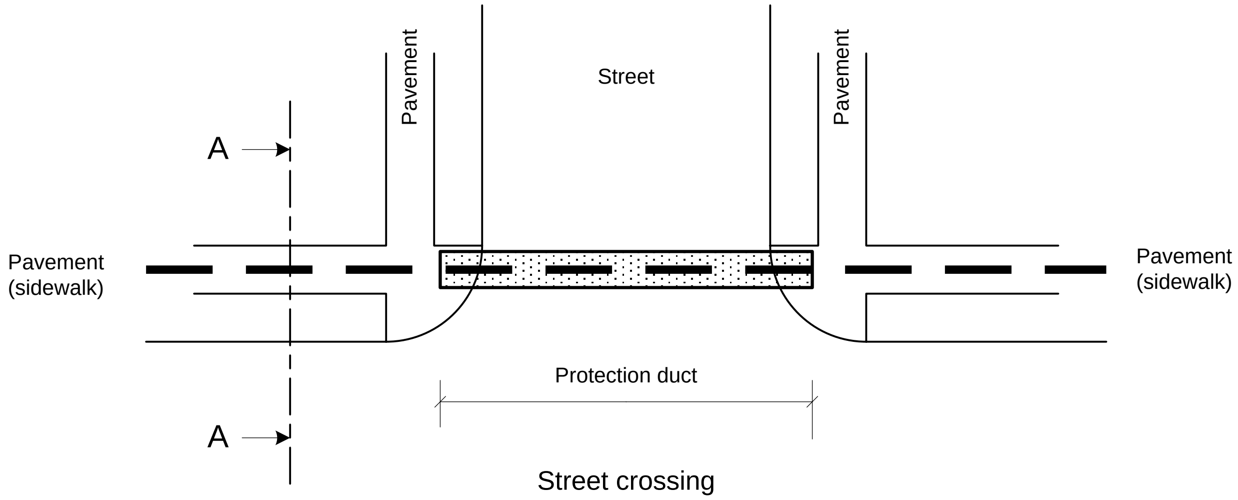
Drawing:
U | **T-004.1**



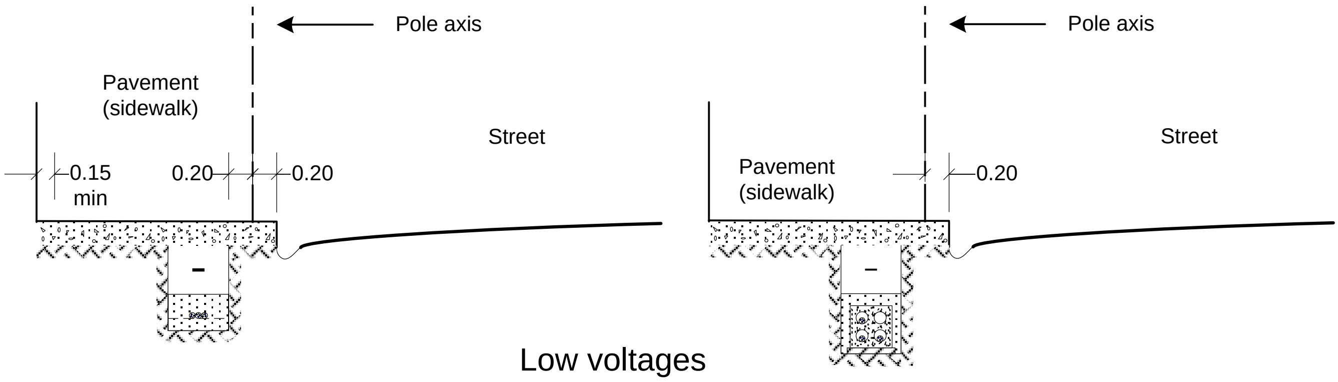
Example of how to drill a hole to put the conduits to street crossing
Note: Type of applied equipment shall be at the Contractors discretion.
These special cases apply only where open trenches are not permitted.



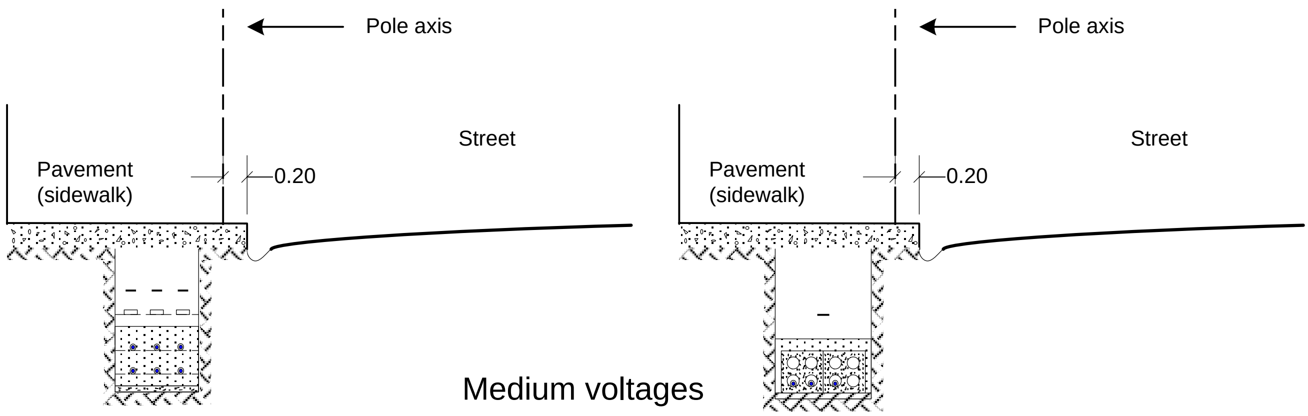
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	STREET CROSSING IN CONDUIT Special case	Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: October, 2004 | Revision: 1.1 | Scale: Without	U T-005



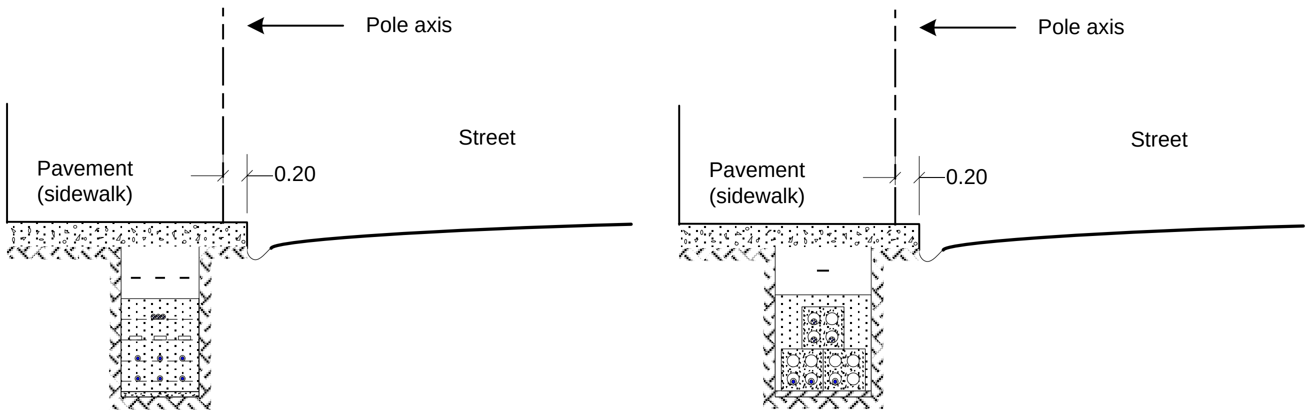
Street crossing
(plant view)



Low voltages

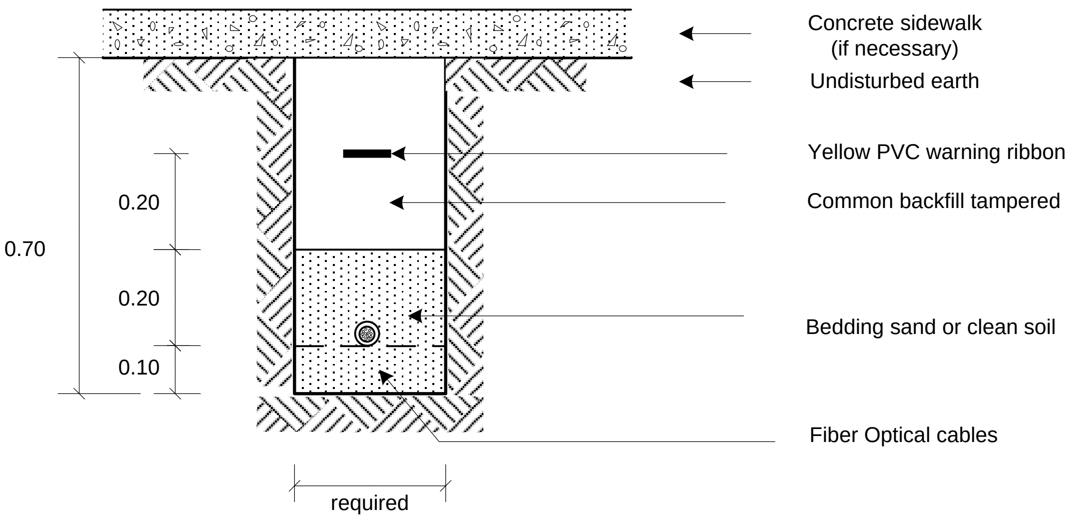


Medium voltages



Low and medium voltages

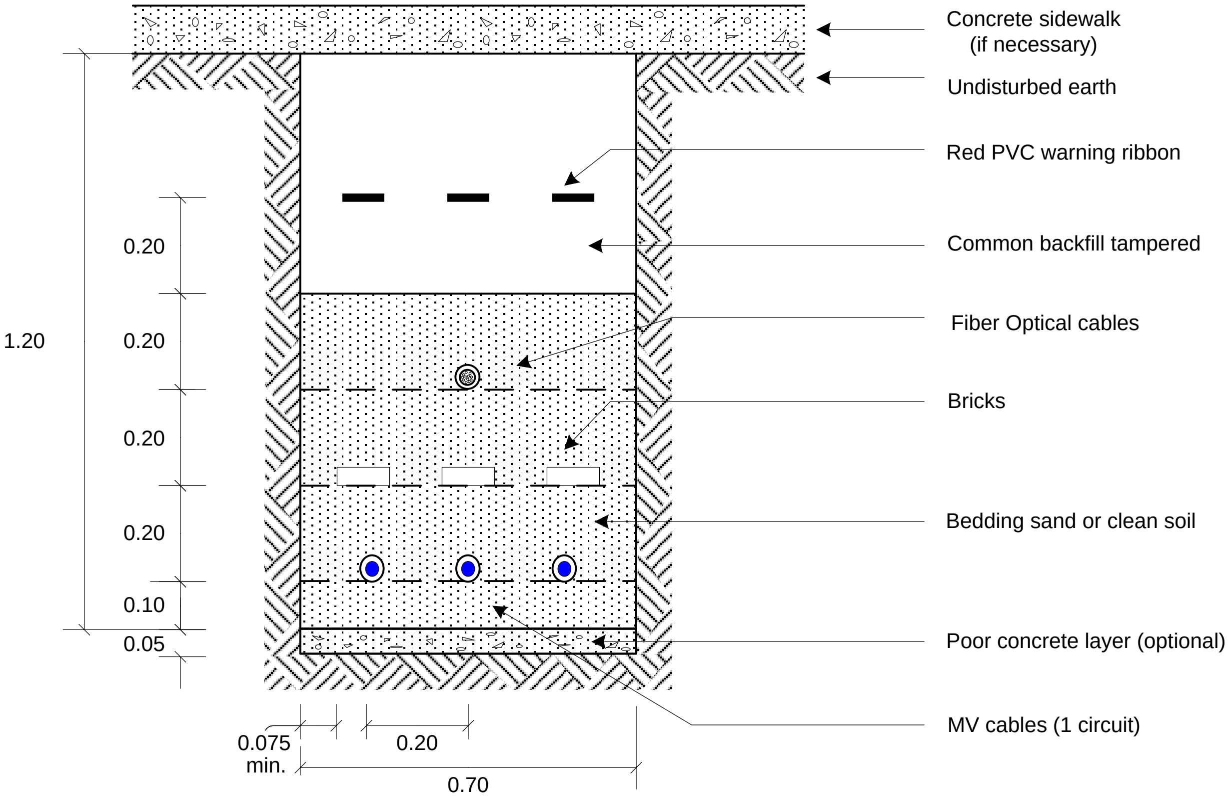
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	STREET CROSSING AND SECTIONS	Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: October, 2004 — Revision: 1 — Scale: Without	U — T-006



OPTICAL CABLE BASIC UNIT
T-007

Depth and width as specified are minimum.
Depth specified is to finish grade.
Sand bedding is not part of this unit and will be specified as needed. Backfilling is part of all trench units.
Backfill shall be placed in uniform layers, ten centimeters thick, on both sides of the cables and thoroughly compacted with pneumatic or hand tampers.
Warning tape shall be placed above the installed cable.
Contractor shall repair any damages immediately

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH	TRENCHES FOR DIRECT BURIAL CABLES – Optical cable			Drawing:	
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1.1	Scale: Without	**U**	**T-007**



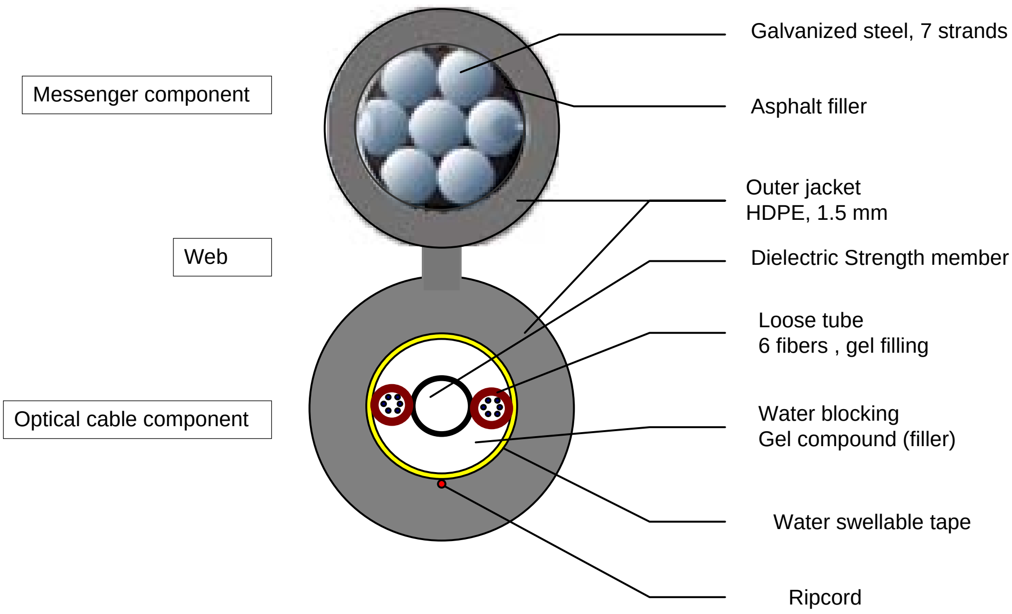
FIBER OPTICAL CABLES
AND MEDIUM VOLTAGE CABLES

Depth and width as specified are minimum.
Depth specified is to finish grade.
Sand bedding is not part of this unit and will be specified as needed. Backfilling is part of all trench units.
Backfill shall be placed in uniform layers, ten centimeters thick, on both sides of the cables and thoroughly compacted with pneumatic or hand tampers.
A layer of solid bricks alert future excavations about danger below. The bricks shall be put with the mayor dimensions across the cable axis.
Warning tape shall be placed above the installed cable.
Contractor shall repair any damages immediately.

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	TRENCHES FOR DIRECT BURIAL CABLES – Optical Cable and Medium Voltage		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1.1	Scale: Without	U	**T-009**

FO-1	Figure-8 loose tube stranded self - supporting cable
FO-2	Loose tube stranded armored cable for direct burial installations
FO-3	Installation Optical Cable Type figure-8
FO-4	Installation Optical Cable Type figure-8
FO-5	Installation Optical Cable Type figure-8
FO-6	Installation Optical Cable Type figure-8
FO-7	Installation Optical Cable Type figure-8
FO-8	Single layer Optical ground wire (OPGW)

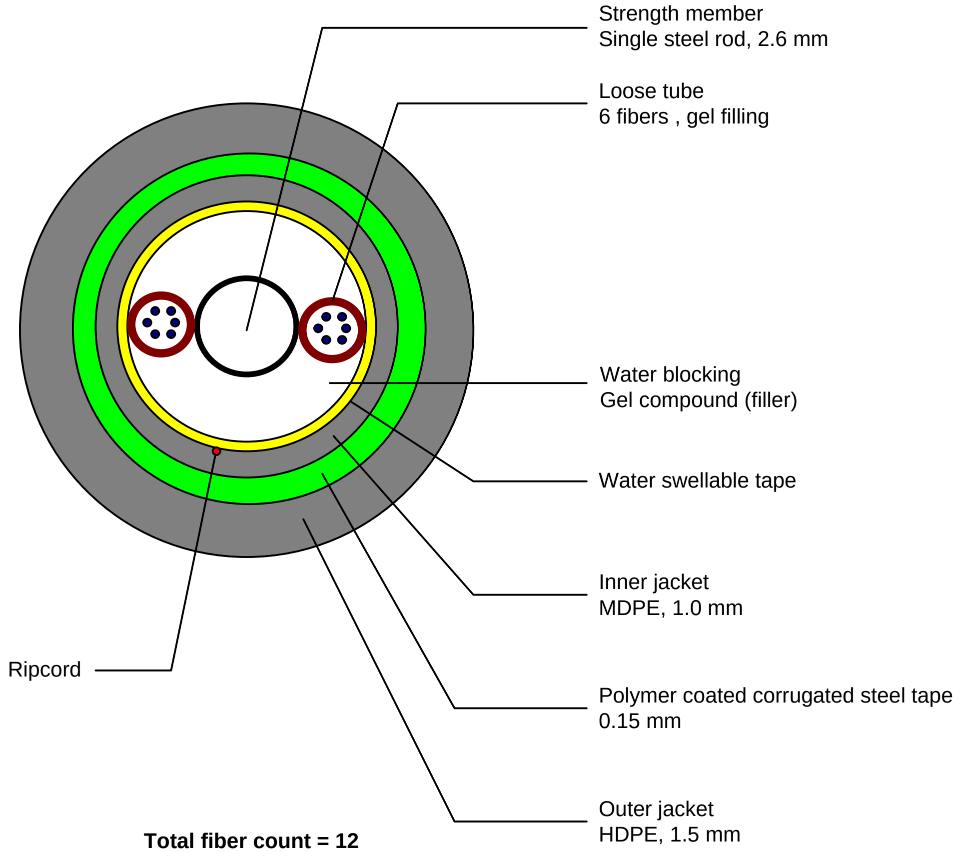
Figure - 8 loose tube stranded self - supporting cable



Total fiber count = 12

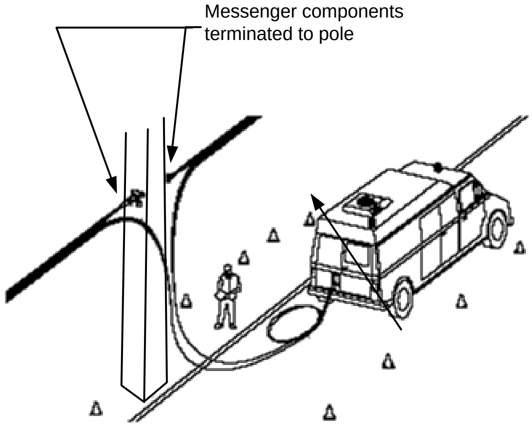
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Figure-8 loose tube stranded self - supporting cable			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	**U** **FO-1**

Loose tube stranded armored cable for direct burial installations

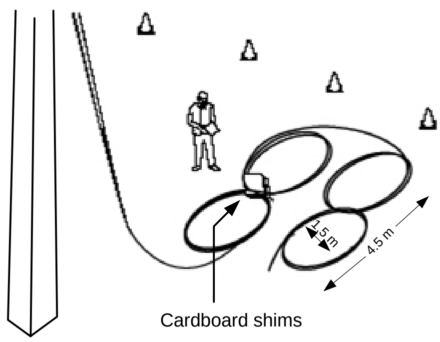


Total fiber count = 12

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Loose tube stranded armored cable for direct burial installations			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U FO-2

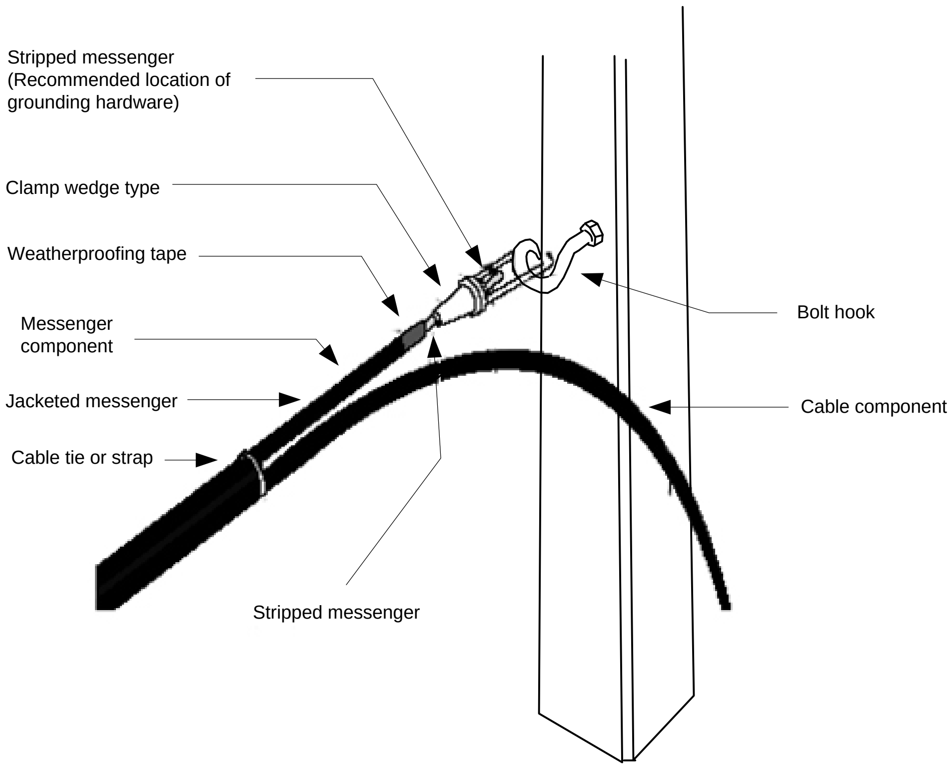


FO-3a

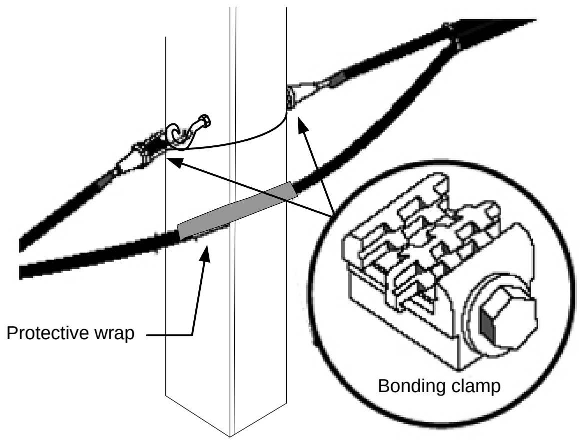


FO-3b

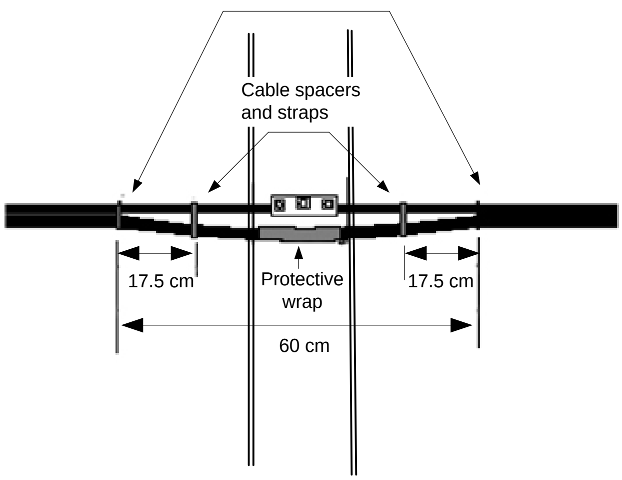
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Installation Optical Cable Type figure-8			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U FO-3



Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Installation Optical Cable Type figure-8			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U FO-4

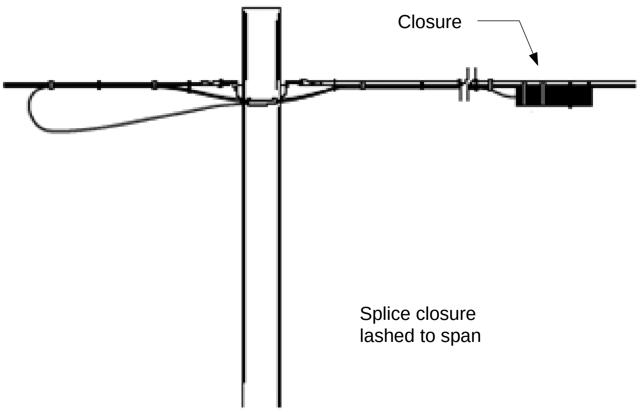


FO-5a

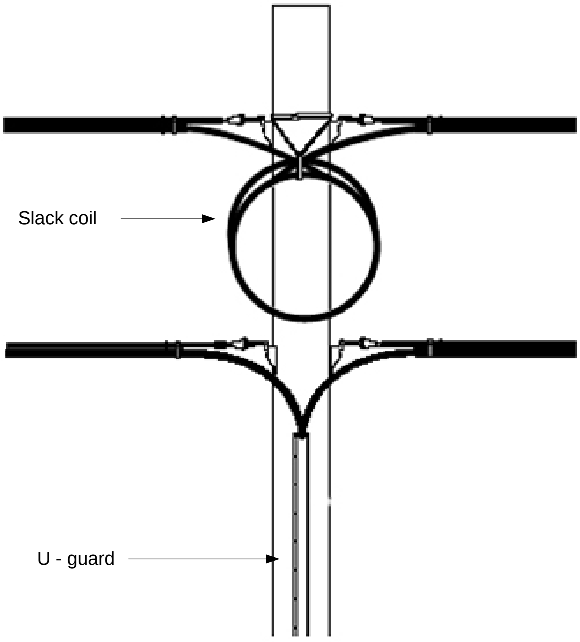


FO-5b

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Installation Optical Cable Type figure-8			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U **FO-5**

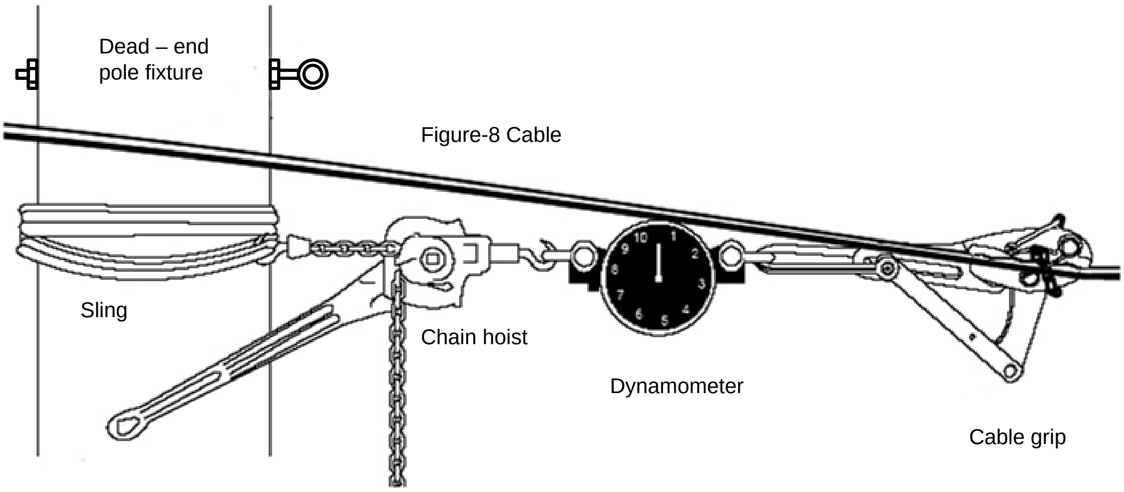


FO-6a



FO-6b

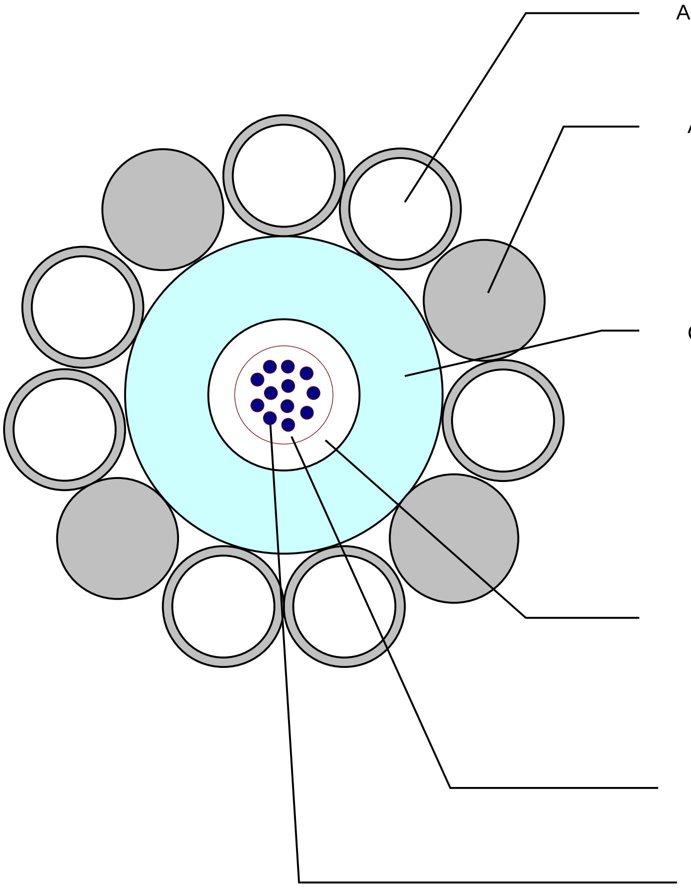
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Installation Optical Cable Type figure-8			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	**U** **FO-6**



Tensioning set-up

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Installation Optical Cable Type figure-8			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U FO-7

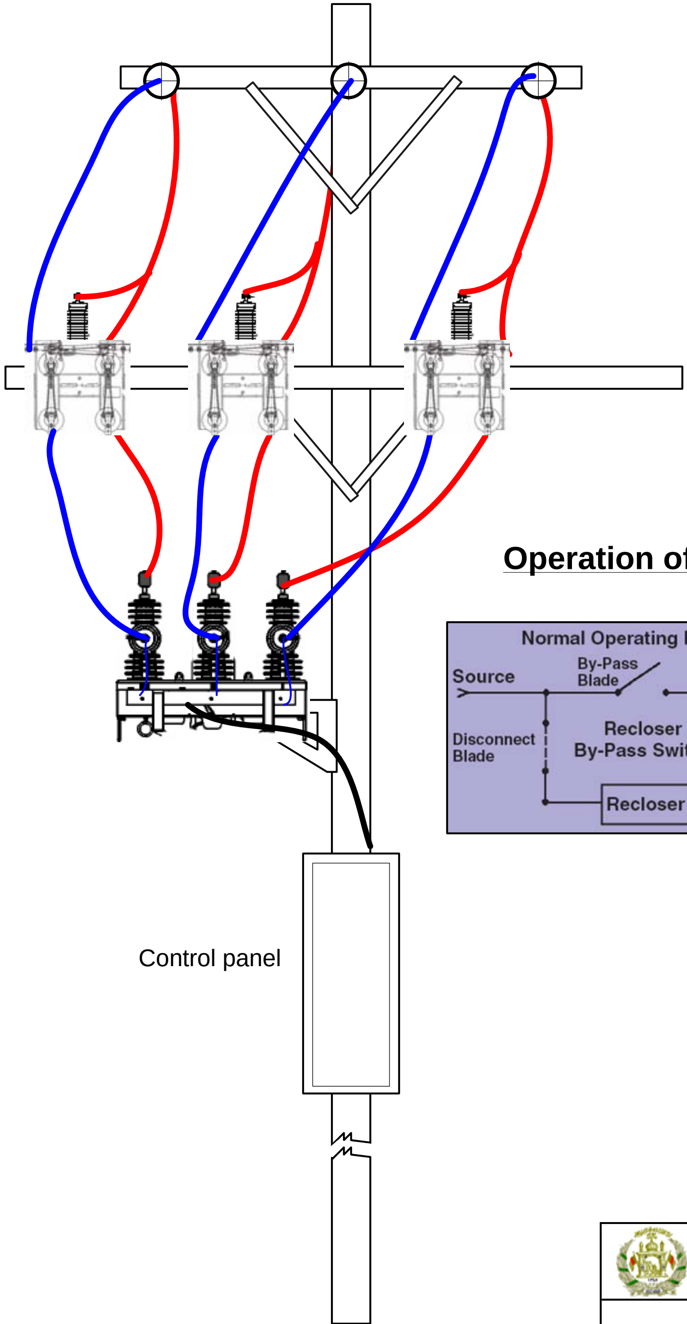
Single layer - Optical ground wire (OPGW)



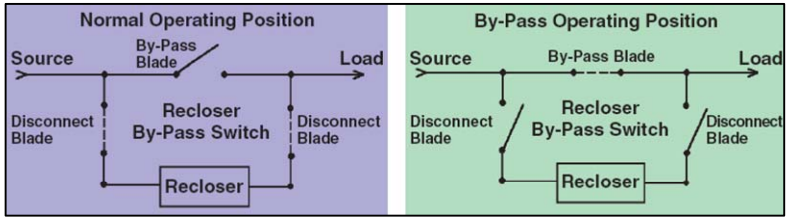
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single layer Optical ground wire (OPGW)			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U **FO-8**

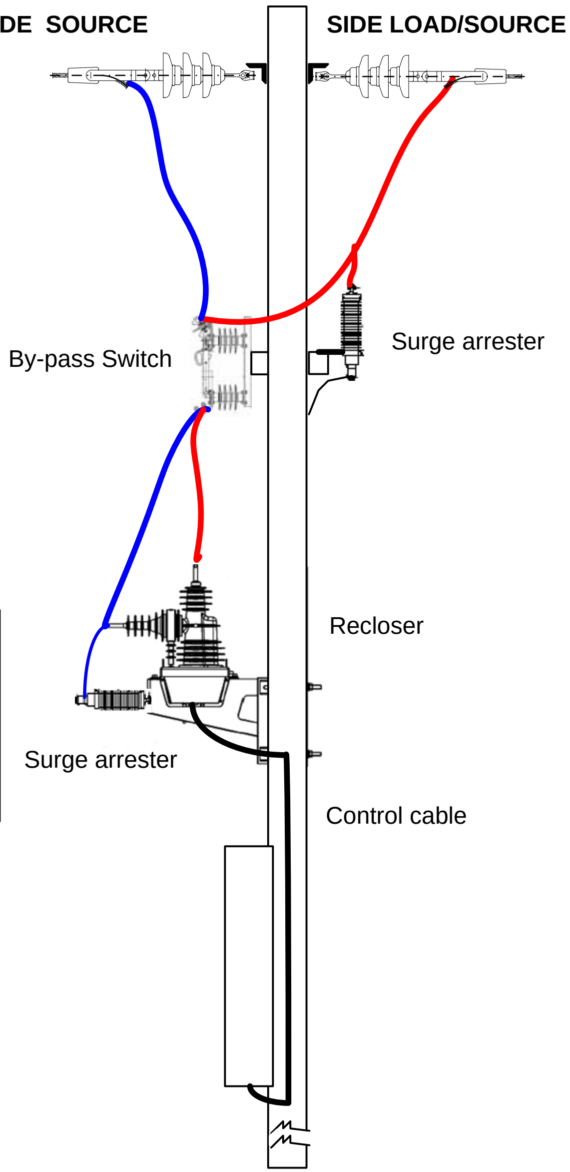
PR-01	RECLOSER WITH BY-PASS SWITCH
PR-02	RECLOSER WITHOUT BY-PASS SWITCH
PR-03	Load Break Switch
PR-04	Single support on cross arm Disconnecting Switch
PR-05	Outgoing cable to overhead line

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Switching Equipment			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1	Scale: Without	U **PR-00**

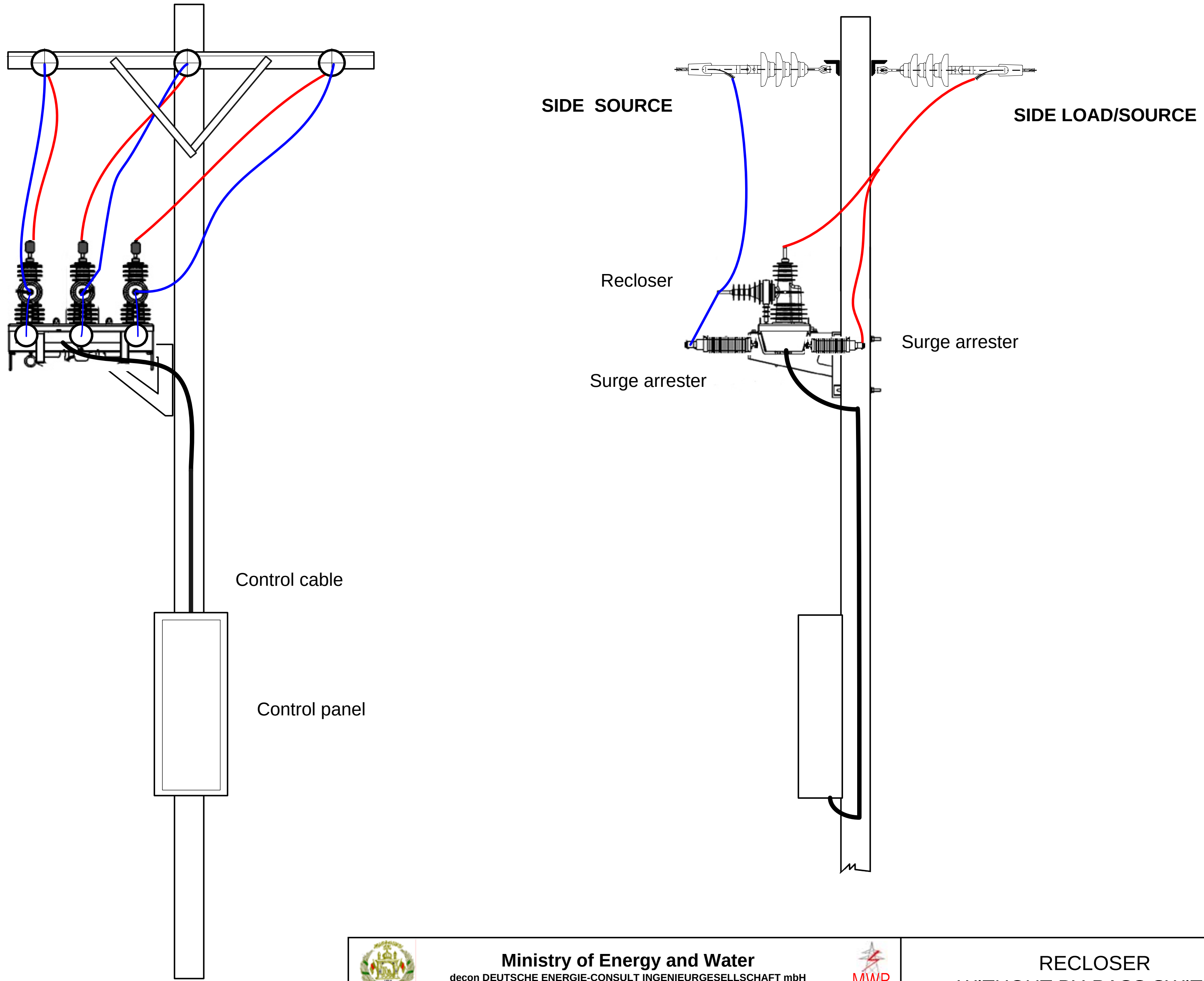


Operation of Recloser-by-Pass arrangement

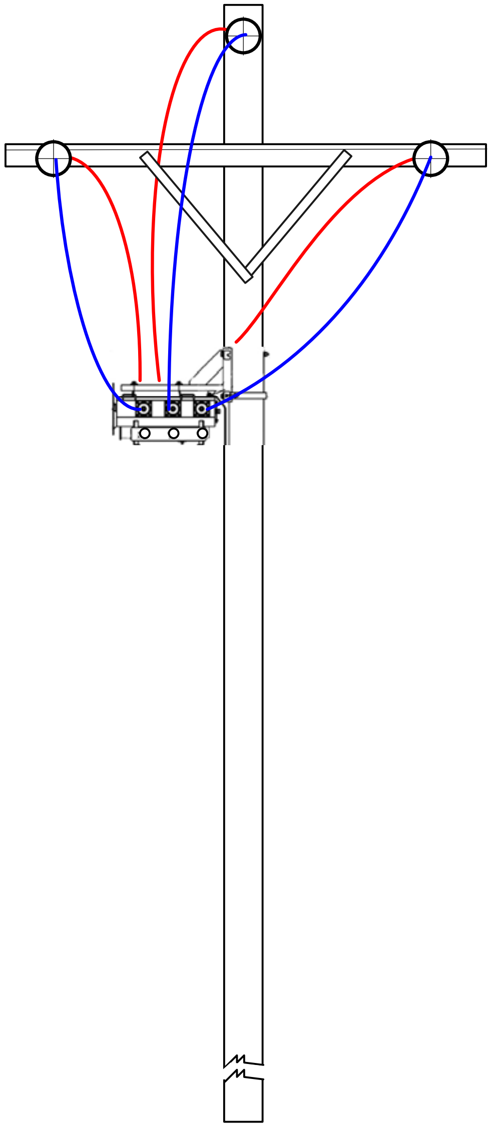


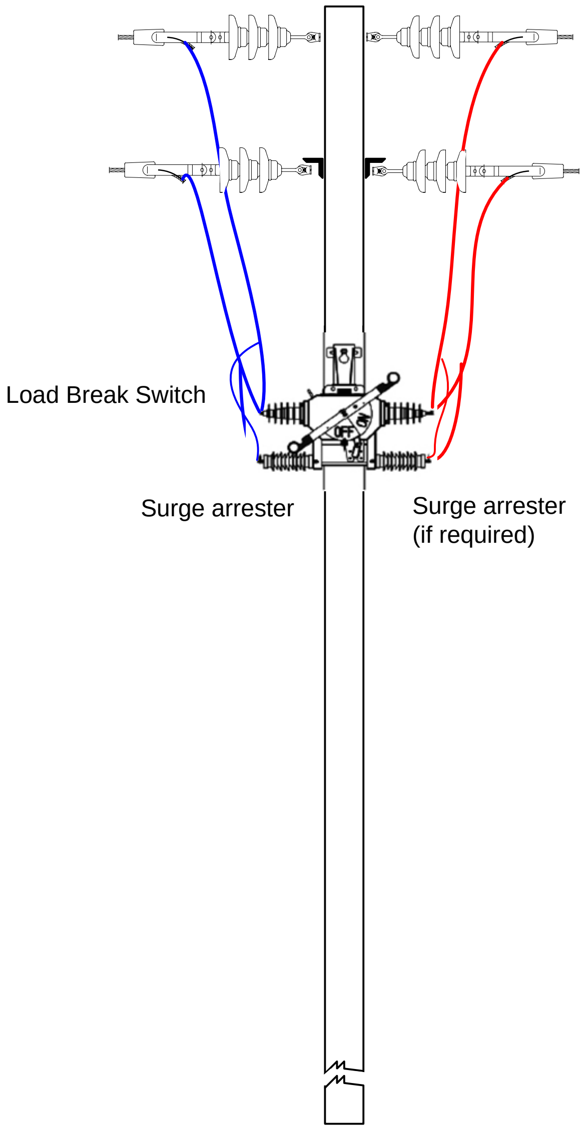


Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	RECLOSER WITH BY-PASS SWITCH		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1.1	Scale: Without
		U	**PR-01**

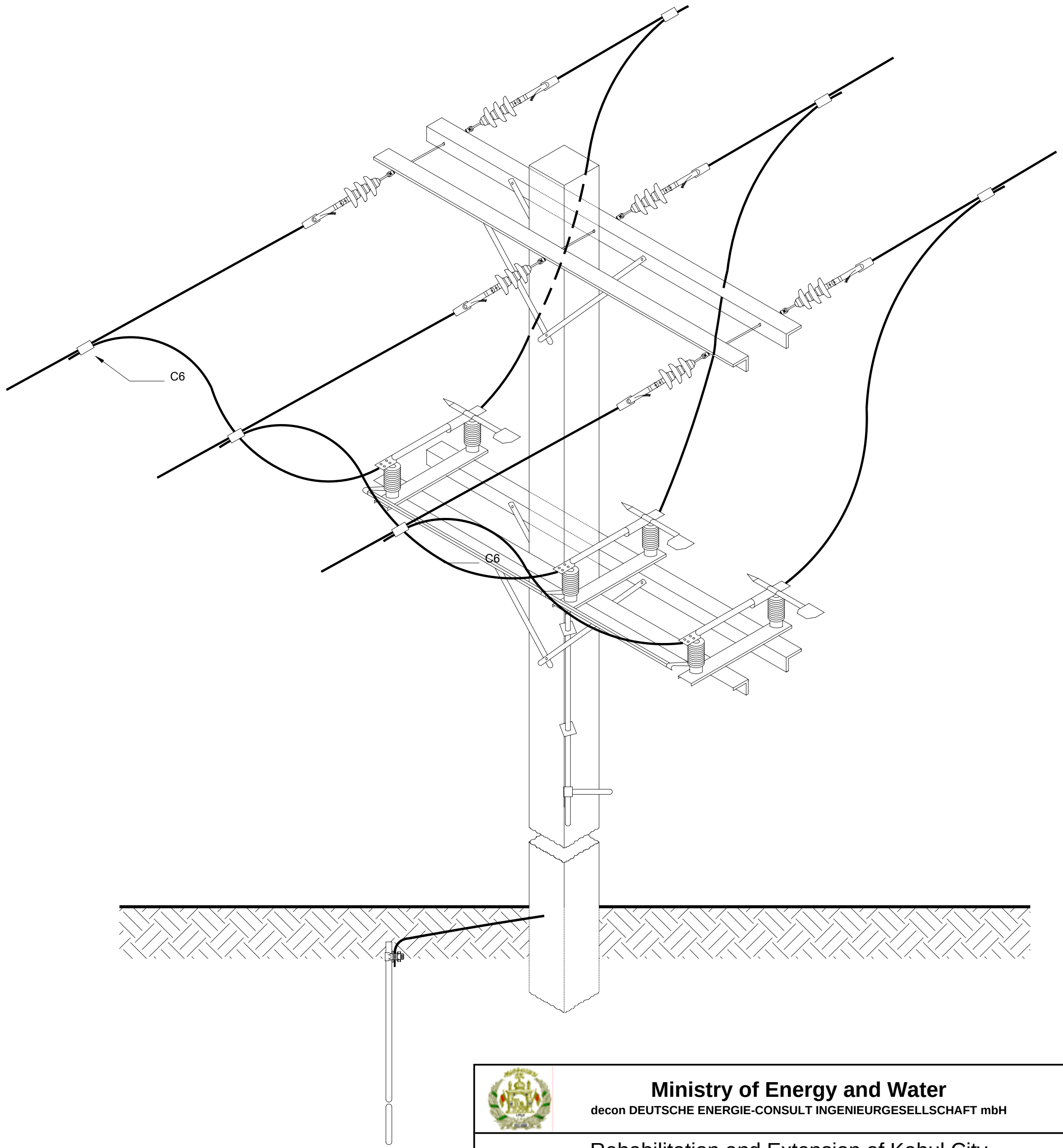


Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	RECLOSER WITHOUT BY-PASS SWITCH		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1	Scale: Without	U	**PR-02**

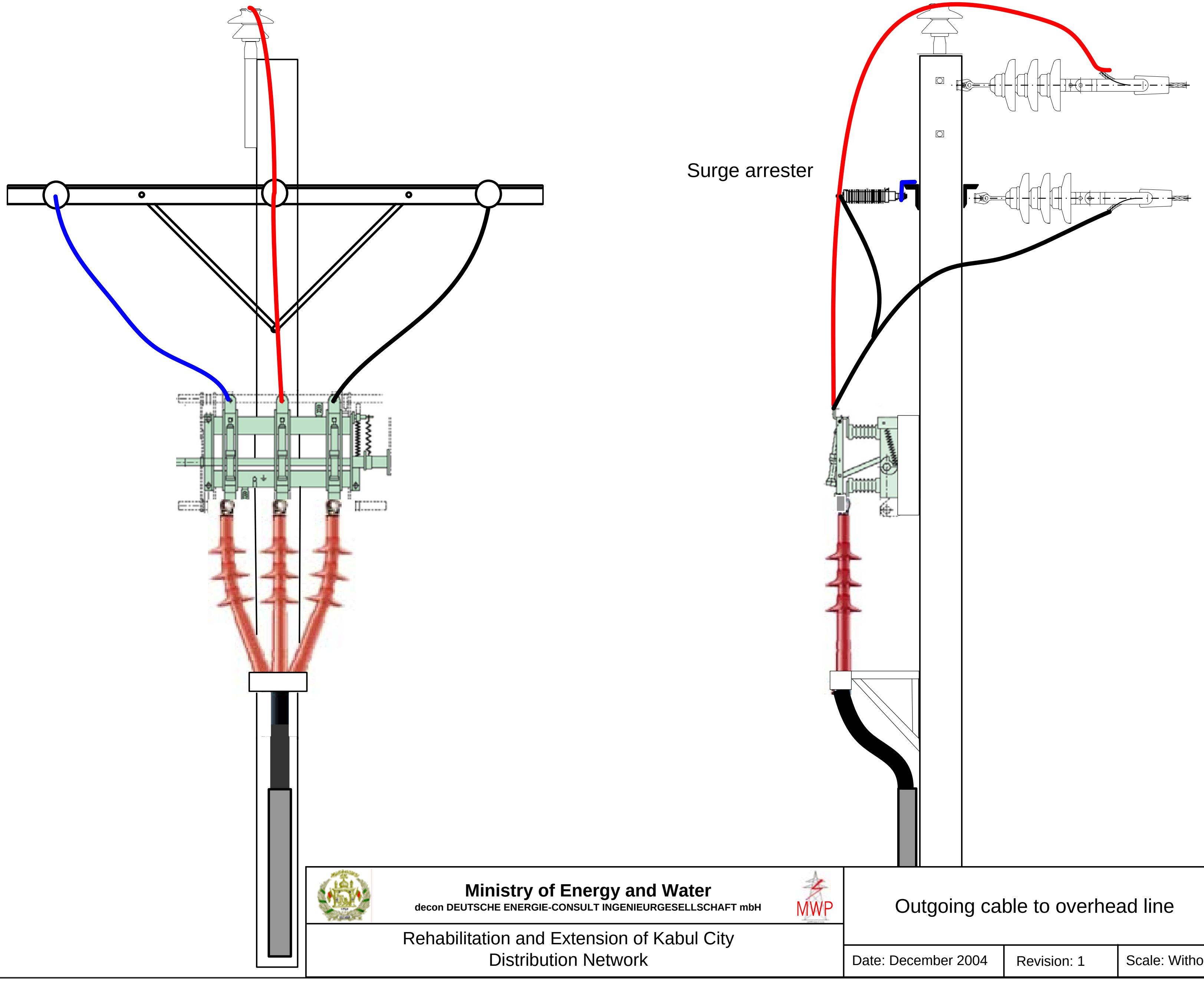




Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Load Break Switch		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004 | Revision: 1 | Scale: Without	U	**PR-03**



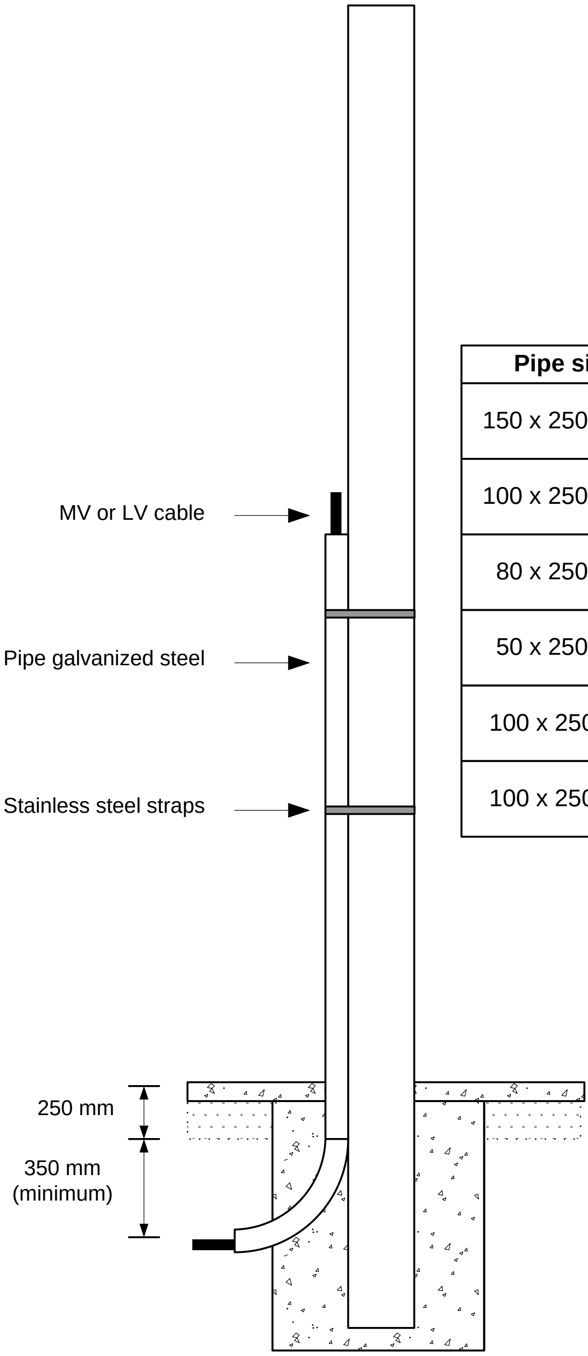
Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single support on cross arm Disconnecting Switch	Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004 · Revision: 1 · Scale: Without	U · PR-04



Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Outgoing cable to overhead line			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1	Scale: Without	U PR-05

M-001	Conduits installation
M-002	Pad-mounted Feeder Pillar and Meter box
M-003	Pole-mounted Meter box
CT-01	Concrete trench

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	MISCELLANEOUS			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 2	Scale: Without	**U** **M-0**



Pipe size	Destination
150 x 2500 mm	For LV Cable – pole mounted transformer 400 kVA 6 (1 x 240 mm2 NYY) + 1 x 120 mm2 NYY
100 x 2500 mm	For LV Cable – pole mounted transformer 250 kVA 3 (1 x 120 mm2 NYY) + 1 x 120 mm2 NYY
80 x 2500 mm	For LV Cable – OHL to feeder pillars or meter boxes (4 x 150 mm2 NYCWY) or (4 x 120 mm2 NYCWY)
50 x 2500 mm	For LV Cable – OHL to feeder pillars or meter boxes (4 x 50 mm2 NYCWY)
100 x 2500 mm	For MV Cable 12/20 kV – Outgoing to OHL 3 (1 x 240 RM/25)
100 x 2500 mm	For MV Cable 12/20 kV – Outgoing to OHL 3 (1 x 120 RM/16)

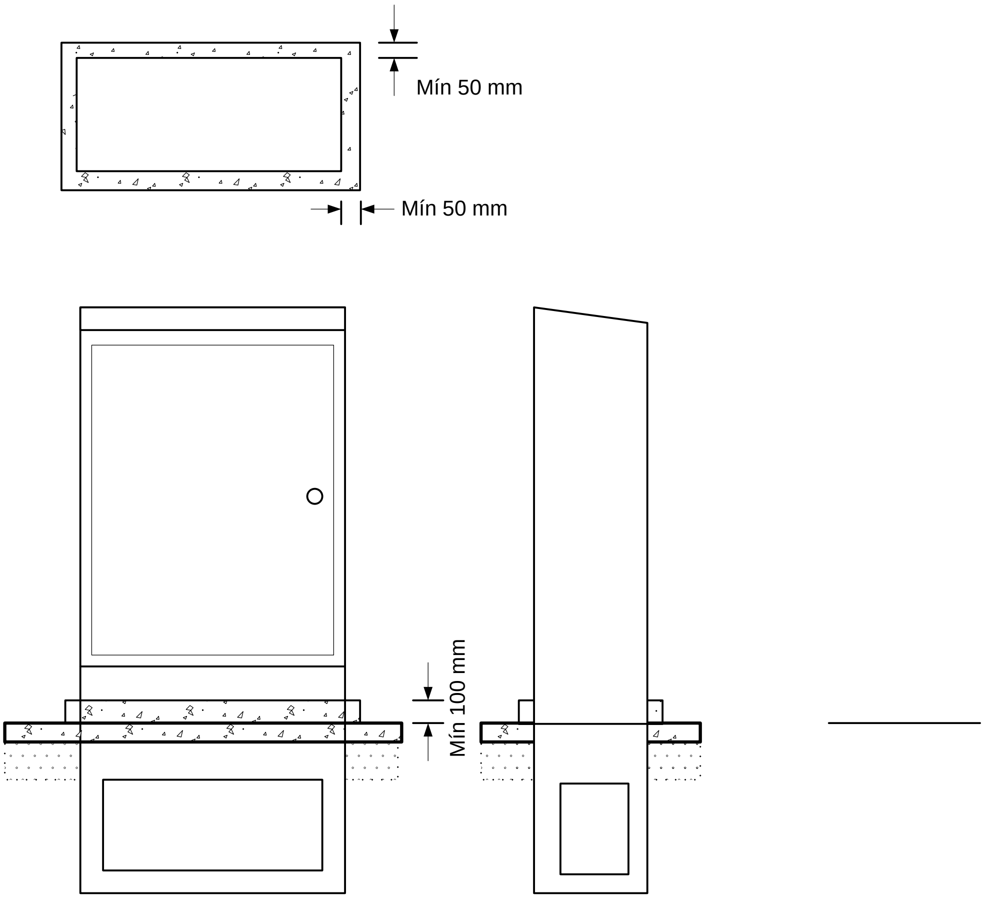
Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH
MWP

Rehabilitation and Extension of Kabul City Distribution Network

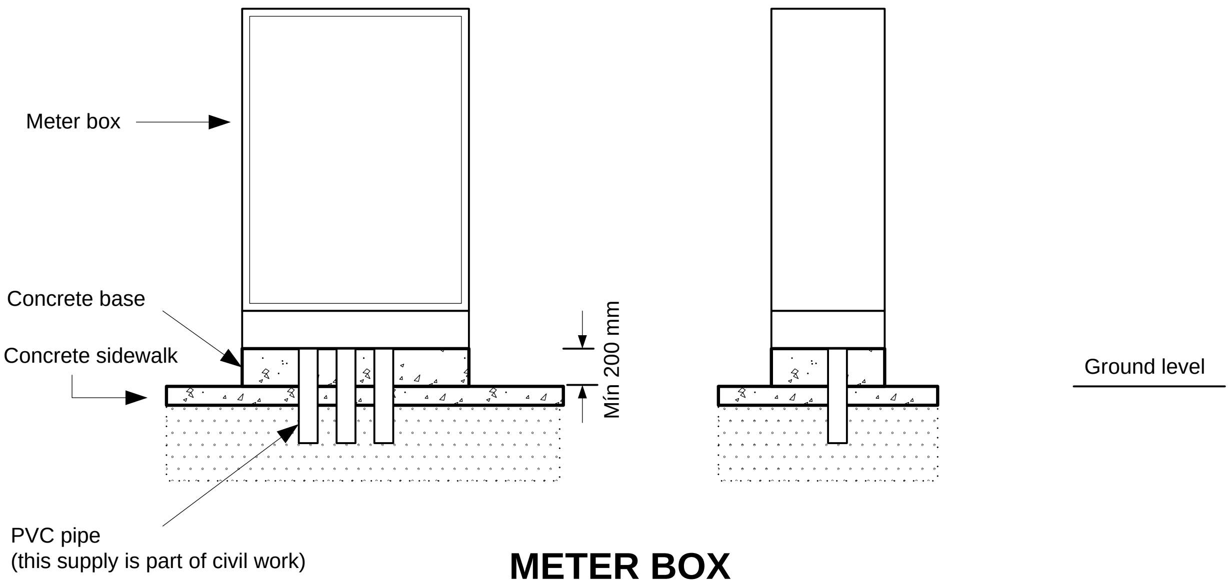
Conduits installation

Date: December 2004 | Revision: 1 | Scale: Without

Drawing: U M-001

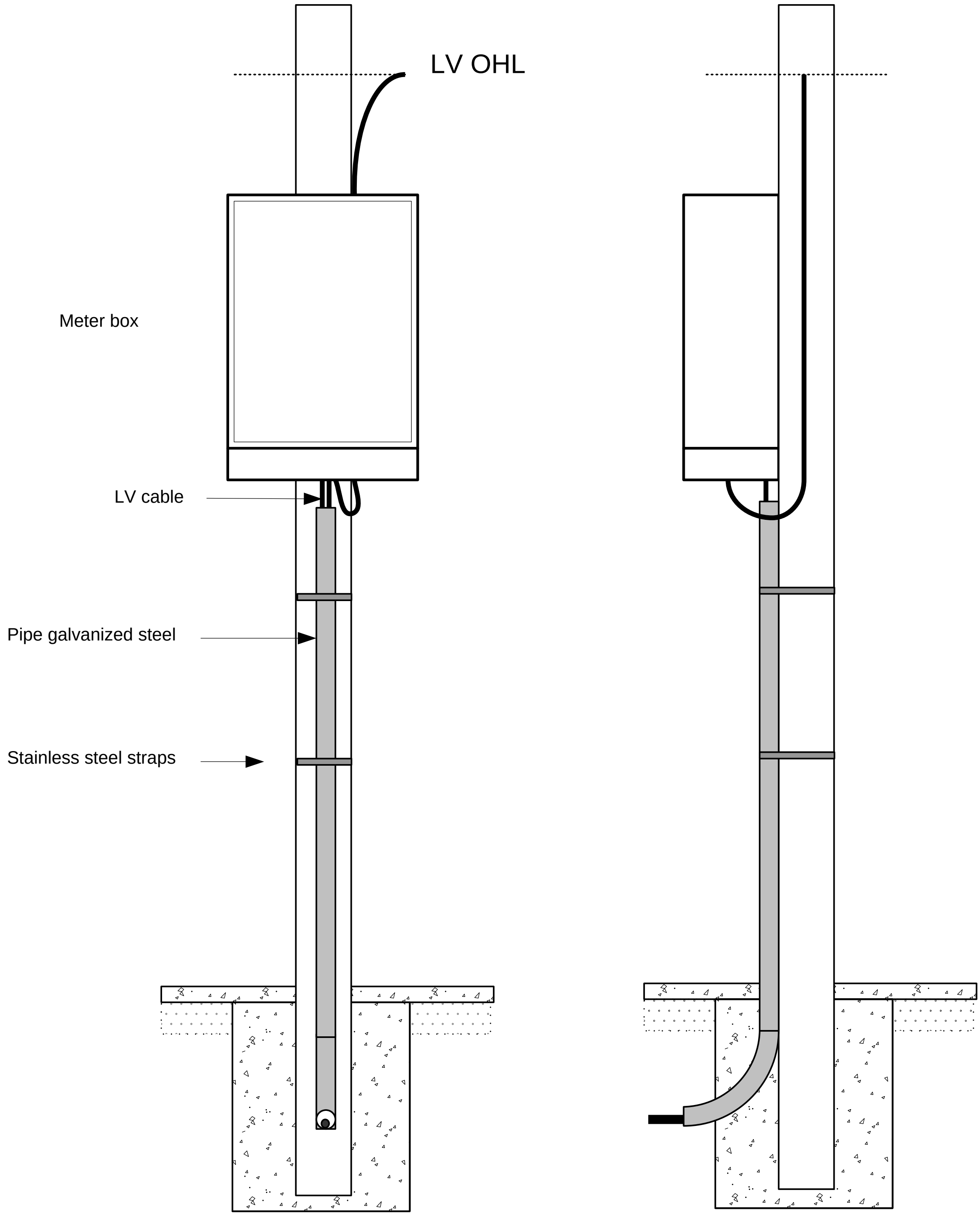


FEEDER PILLAR

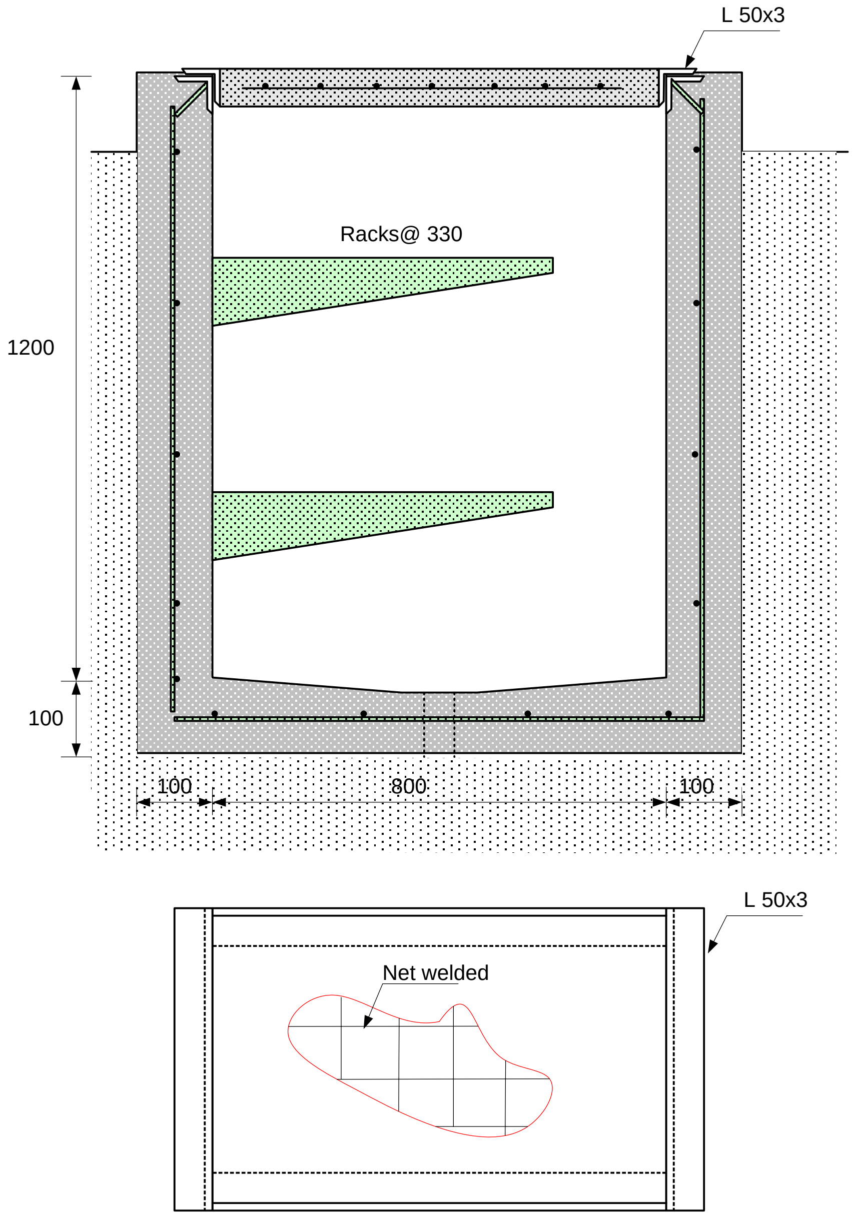


METER BOX

Ministry of Energy and Water **decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH** MWP	Pad-mounted Feeder Pillar and Meter box			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 2	Scale: Without	**U** **M-002**



Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Pole-mounted Meter box		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1	Scale: Without	U **M-003**



Ministry of Energy and Water
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH
MWP

Rehabilitation and Extension of Kabul City
Distribution Network

Concrete trench

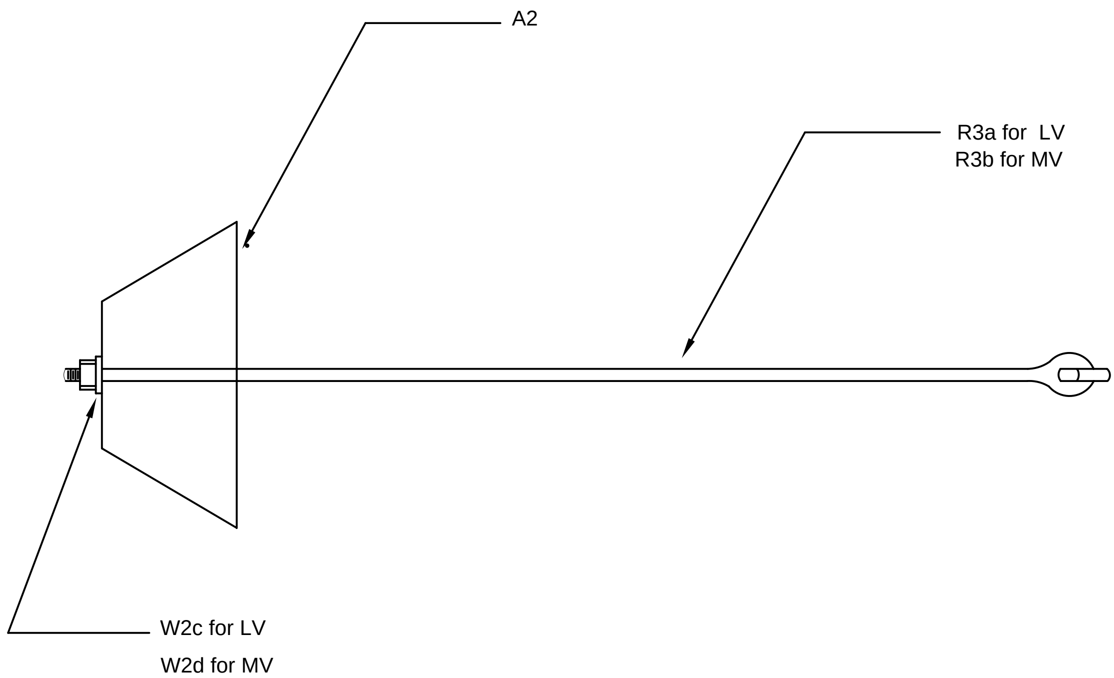
Date: March 2005	Revision: 1	Scale: Without	U	Drawing: CT-001

PAGE 1 - 3

MISCELLANEOUS (GUYS AND ANCHOR)

AN-S1	ANCHOR WITH THIMBLEYE ROD
AN-D1	ANCHOR WITH TWINEYE ROD
GU-S1	SINGLE GUY
GU-O1	SINGLE OVERHEAD GUY

GU-101C	SINGLE DOWN GUY FOR LOW VOLTAGE
GU-102C	SINGLE DOWN GUY FOR MEDIUM VOLTAGE
GU-201C	TWO DOWN GUYS FOR LOW /MEDIUM VOLTAGE
GU-202C	TWO DOWN GUYS WITH ONE ANCHOR
GU-301C	THREE DOWN GUYS FOR MEDIUM VOLTAGE
GU-401C	SINGLE OVERHEAD GUY



Assembly	AN-S1.1	AN-S1.2		
NO.	QT.	QT.	DESCRIPTION	CODE
A2	1	1	CONE ANCHOR, CONCRETE AREA (161,300 mm²)	
R3a	1		THIMBLEYE ANCHOR ROD, M16 X 2000 mm, 70 KN	
R3b		1	THIMBLEYE ANCHOR ROD, M20 X 2400 mm, 100 KN	
W2c	1		SQUARD WASHER 75 mm x 75 mm x 8 mm for bolt M16	
W2d		1	SQUARD WASHER 100 mm x 100 mm x 10 mm for bolt M20	

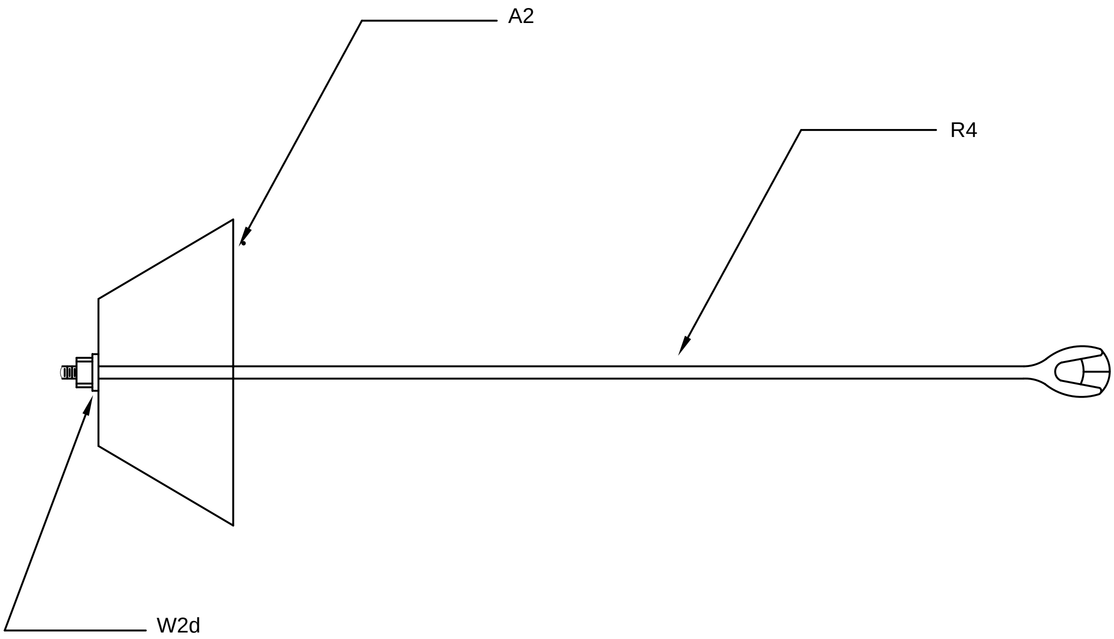
Ministry of Water and Power
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH
MWP

Rehabilitation and Extension of Kabul City Distribution Network

Anchor with thimbleye rod
Miscellaneous assemblies

Date: March, 2005 | Revision: 0 | Scale: Without

Drawing:
U **AN-S1**



NO.	QT.	DESCRIPTION	CODE
A2	1	CONE ANCHOR, CONCRETE AREA (161,300 mm²)	
R4	1	TWINEYE ANCHOR ROD, M20 x 2400 mm	
W2d	1	SQUARD WASHER 100 mm x 100 mm x 10 mm for bolt M20	

Ministry of Water and Power
decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH

MWP

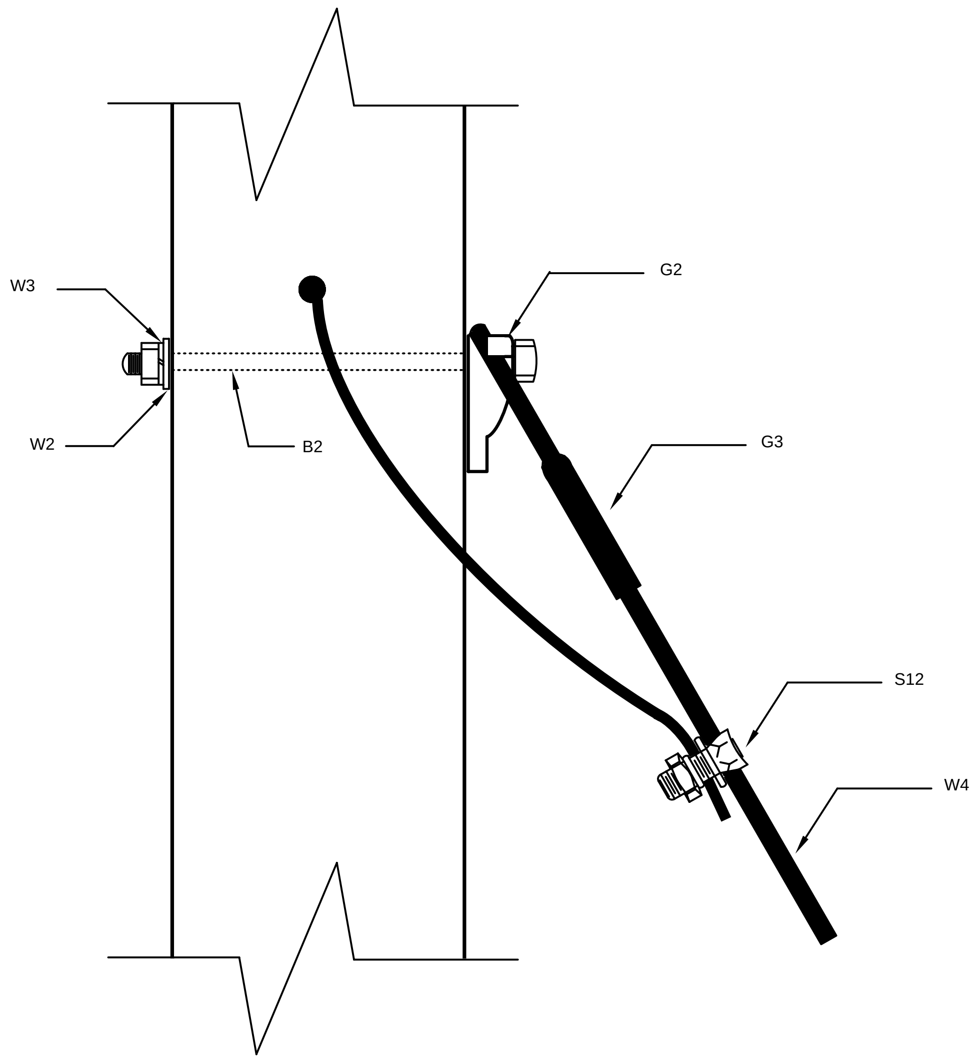
Rehabilitation and Extension of Kabul City
Distribution Network

Anchor with twineye rod
Miscellaneous assemblies

Date: March, 2005 | Revision: 0 | Scale: Without

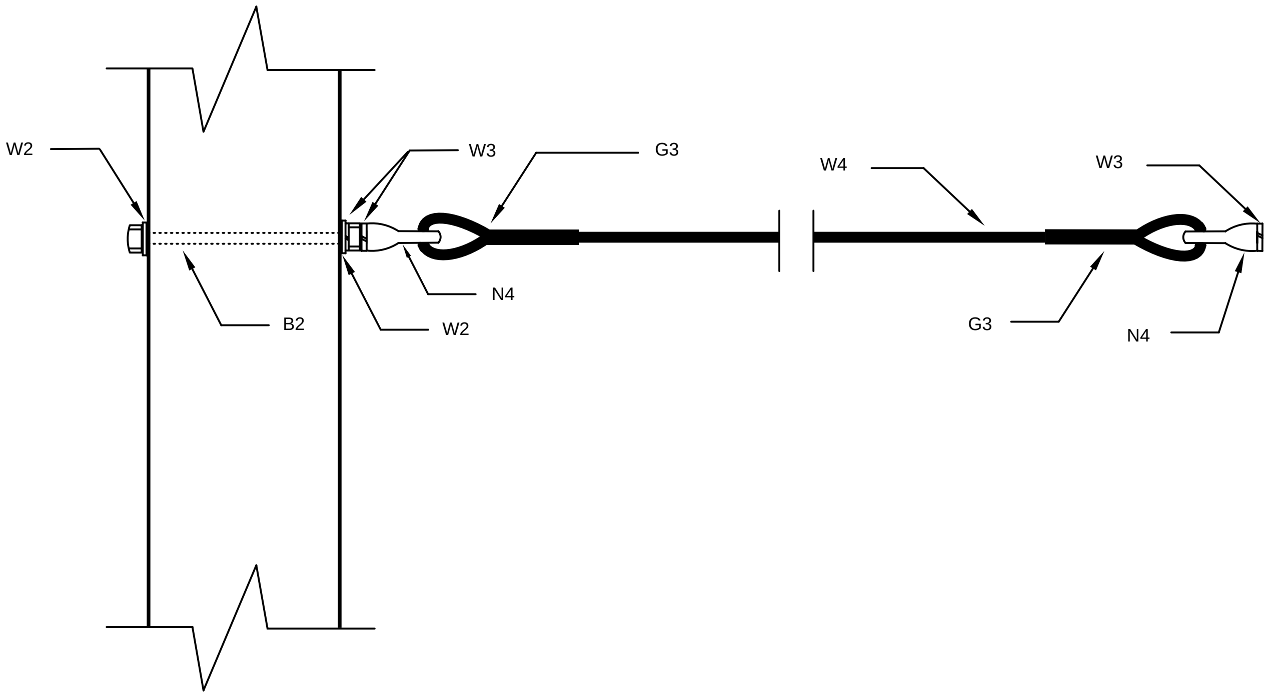
Drawing:

U **AN-D1**



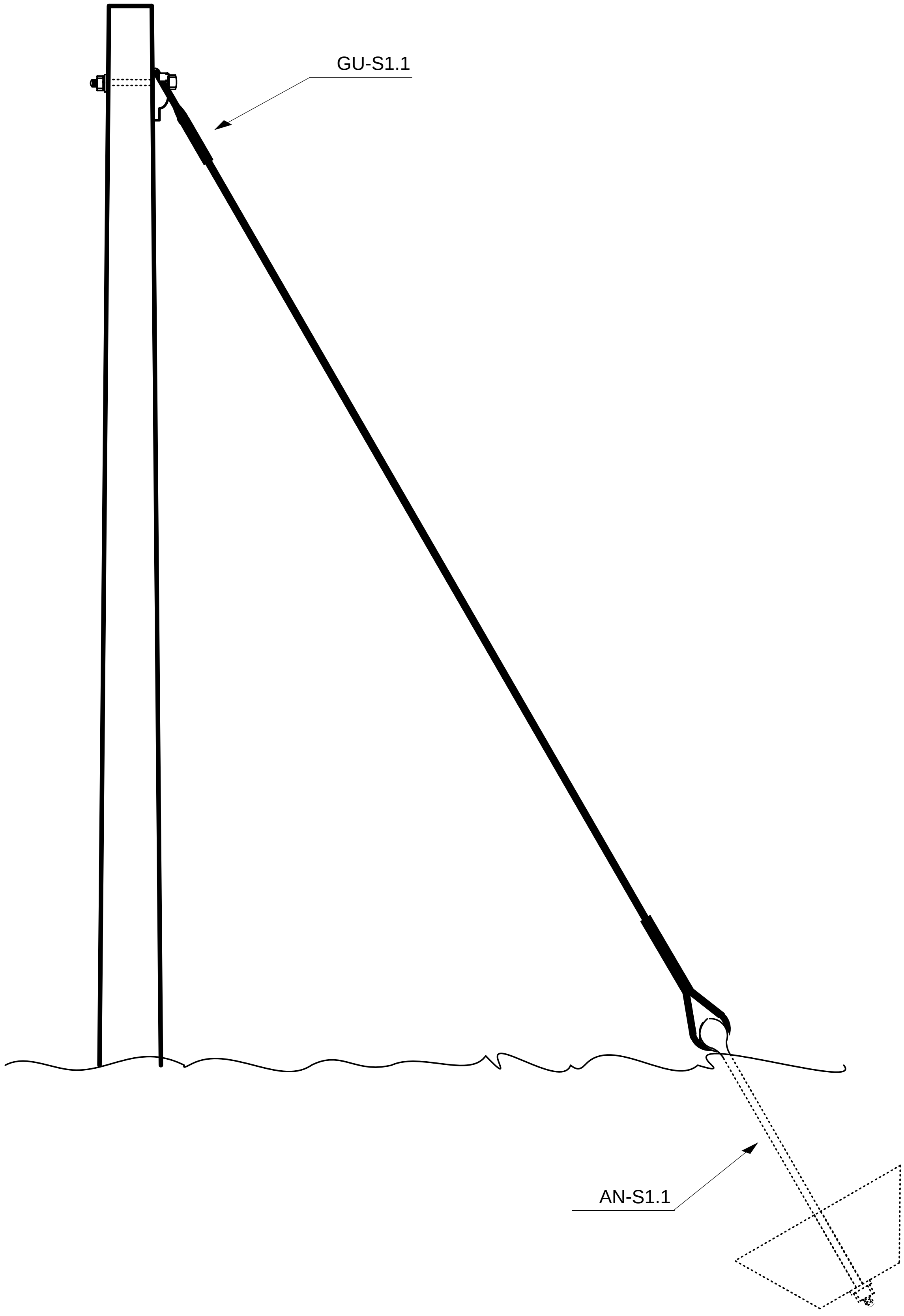
Assembly	GU-S1.1	GU-S1.2		
NO.	QT.	QT.	DESCRIPTION	CODE
B2g	1		MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x 200 mm	
B2j		1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M20 x 250 mm	
G2a	1		GUY HOOK FOR GUY STRAND DIAMETER 7 mm, THRU BOLT M16 , 39 KN ULTIMATE STRENGTH	
G2b		1	GUY HOOK FOR GUY STRAND DIAMETER 11 mm, THRU BOLT M20 , 95 KN ULTIMATE STRENGTH	
G3a	2		GUY END FOR GUY STRAND DIAMETER 7 mm, 36 KN ULTIMATE STRENGTH	
G3b		2	GUY END FOR GUY STRAND DIAMETER 11 mm, 101 KN ULTIMATE STRENGTH	
S12a	1		SPLIT BOLT FOR GUY STRAND DIAMETER 7 mm AND GROUND WIRE DIAMETER 6.4 mm	
S12b		1	SPLIT BOLT FOR GUY STRAND DIAMETER 11 mm AND GROUND WIRE DIAMETER 7.6 mm	
W2c	1		SQUARE WASHER, 75 mm X 75 mm X 8 mm, for bolt M16	
W2d		1	SQUARE WASHER, 100 mm X 100 mm X 10 mm, for bolt M20	
W3c	1		SPRING LOCK WASHER, for bolt M16	
W3d		1	SPRING LOCK WASHER, for bolt M20	
W4a	-		GUY WIRE, STRAND DIAMETER 7 mm, ULTIMATE STREGHT 39 KN (REQ'D LENGTH)	
W4b		-	GUY WIRE, STRAND DIAMETER 11 mm, ULTIMATE STREGHT 95 KN (REQ'D LENGTH)	

Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single guy Miscellaneous assemblies			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: March, 2005	Revision: 0	Scale: Without	U **GU-S1**

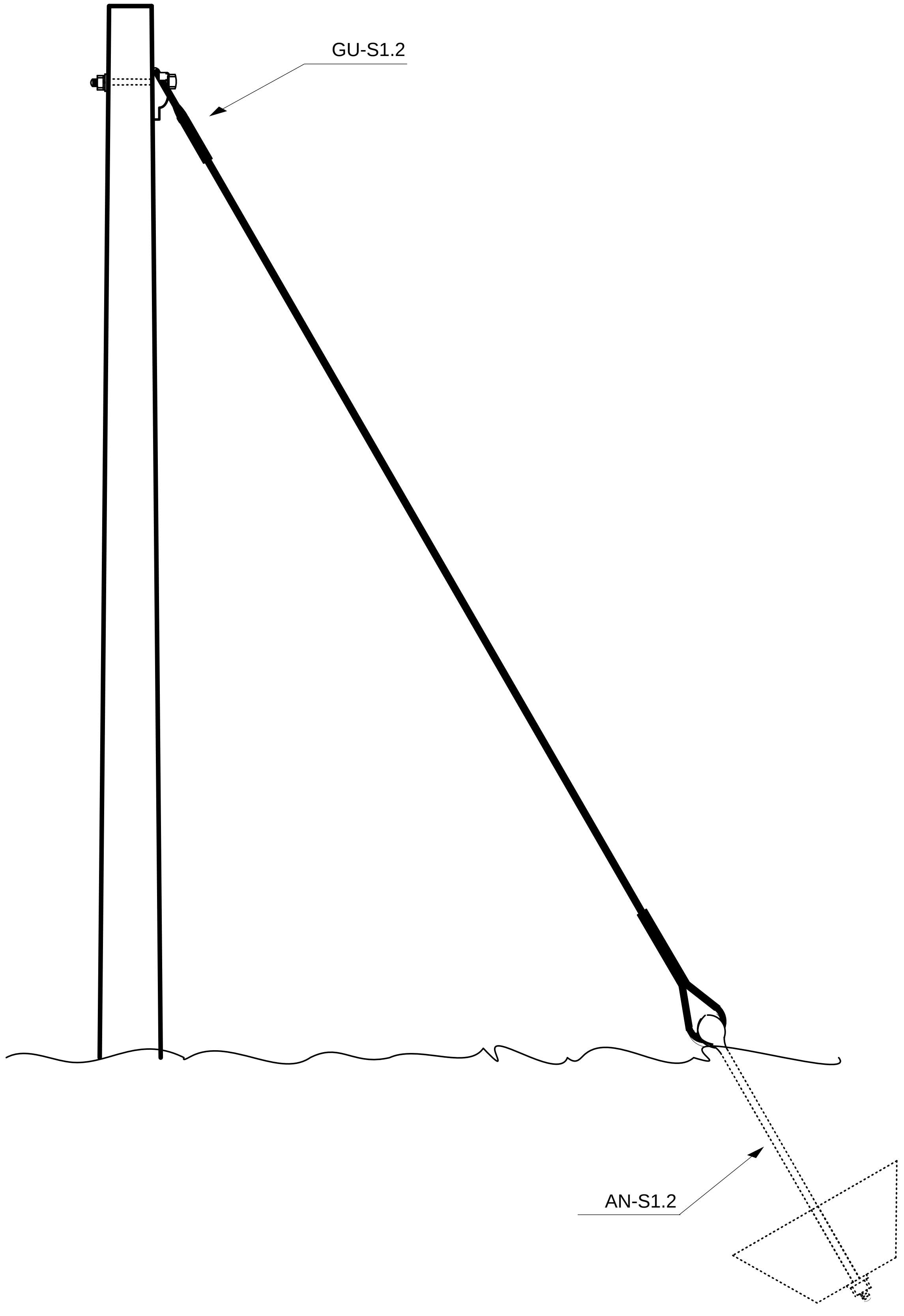


Assembly	GU-O1.1	GU-O1.2		
NO.	QT.	QT.	DESCRIPTION	CODE
B2g	1		MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M16 x 200 mm	
B2j		1	MACHINE BOLT, METRIC THREAD, HEXAGONAL HEAD AND NUT M20 x 250 mm	
G3a	2		GUY END FOR GUY STRAND DIAMETER 7 mm, 36 KN ULTIMATE STRENGTH	
G3b		2	GUY END FOR GUY STRAND DIAMETER 11 mm, 101 KN ULTIMATE STRENGTH	
N4a	2		THIMBLEYENUT for bolt M16 AND GUY STRAND DIAMETER 7 mm, 130 KN ULTIMATE STRENGTH	
N4b		2	THIMBLEYENUT for bolt M20 AND GUY STRAND DIAMETER 11 mm, 130 KN ULTIMATE STRENGTH	
S12a	1		SPLIT BOLT FOR GUY STRAND DIAMETER 7 mm AND GROUND WIRE DIAMETER 6.4 mm	
S12b		1	SPLIT BOLT FOR GUY STRAND DIAMETER 11 mm AND GROUND WIRE DIAMETER 7.6 mm	
W2c	2		SQUARE WASHER, 75 mm X 75 mm X 8 mm, for bolt M16	
W2d		2	SQUARE WASHER, 100 mm X 100 mm X 10 mm, for bolt M20	
W3c	3		SPRING LOCK WASHER, for bolt M16	
W3d		3	SPRING LOCK WASHER, for bolt M20	
W4a	-		GUY WIRE, STRAND DIAMETER 7 mm, ULTIMATE STREGHT 39 KN (REQ'D LENGTH)	
W4b		-	GUY WIRE, STRAND DIAMETER 11 mm, ULTIMATE STREGHT 95 KN (REQ'D LENGTH)	

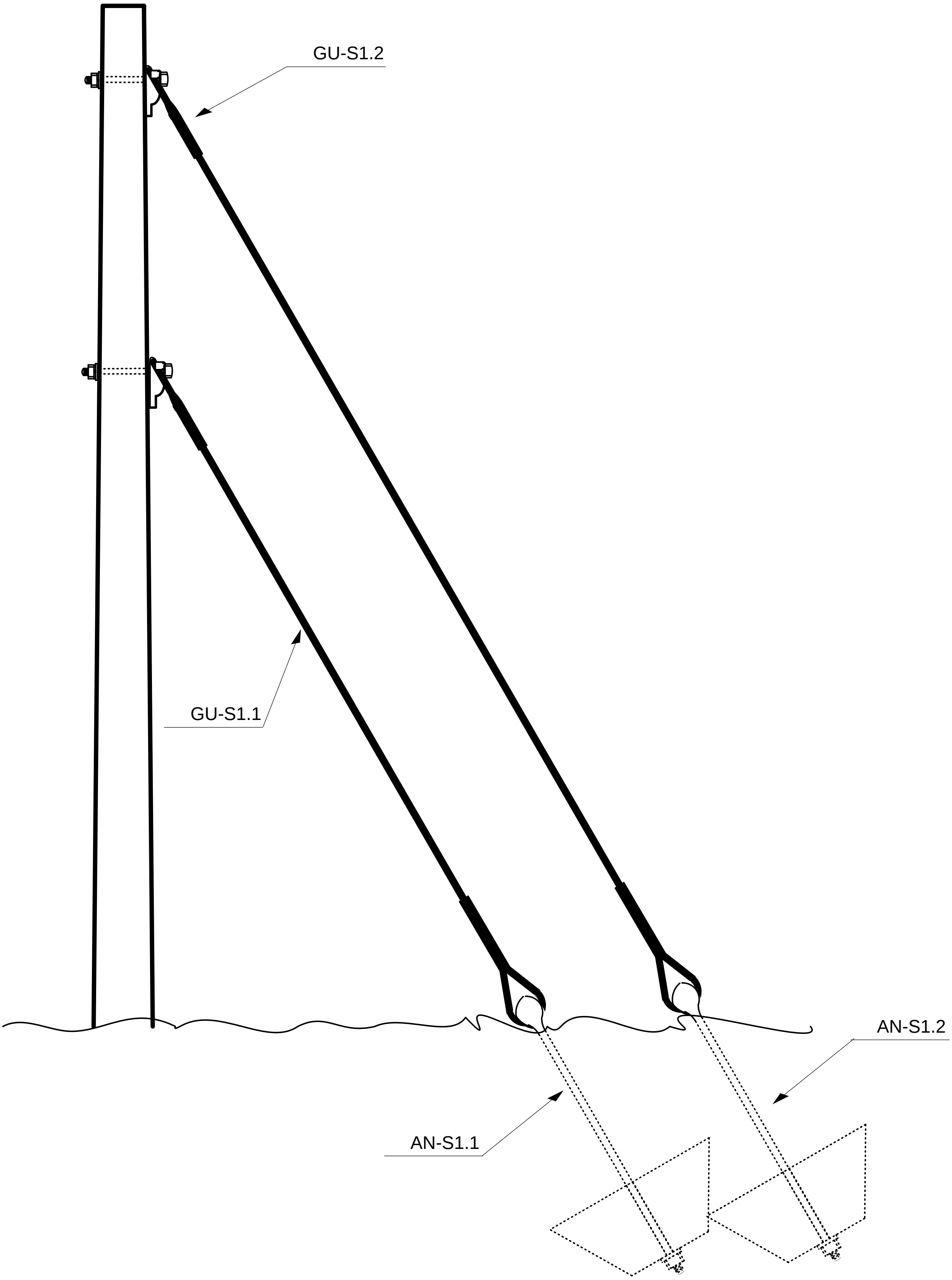
Ministry of Water and Power **decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH** MWP	Single overhead guy Miscellaneous assemblies			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: March, 2005	Revision: 0	Scale: Without	**U** **GU-O1**



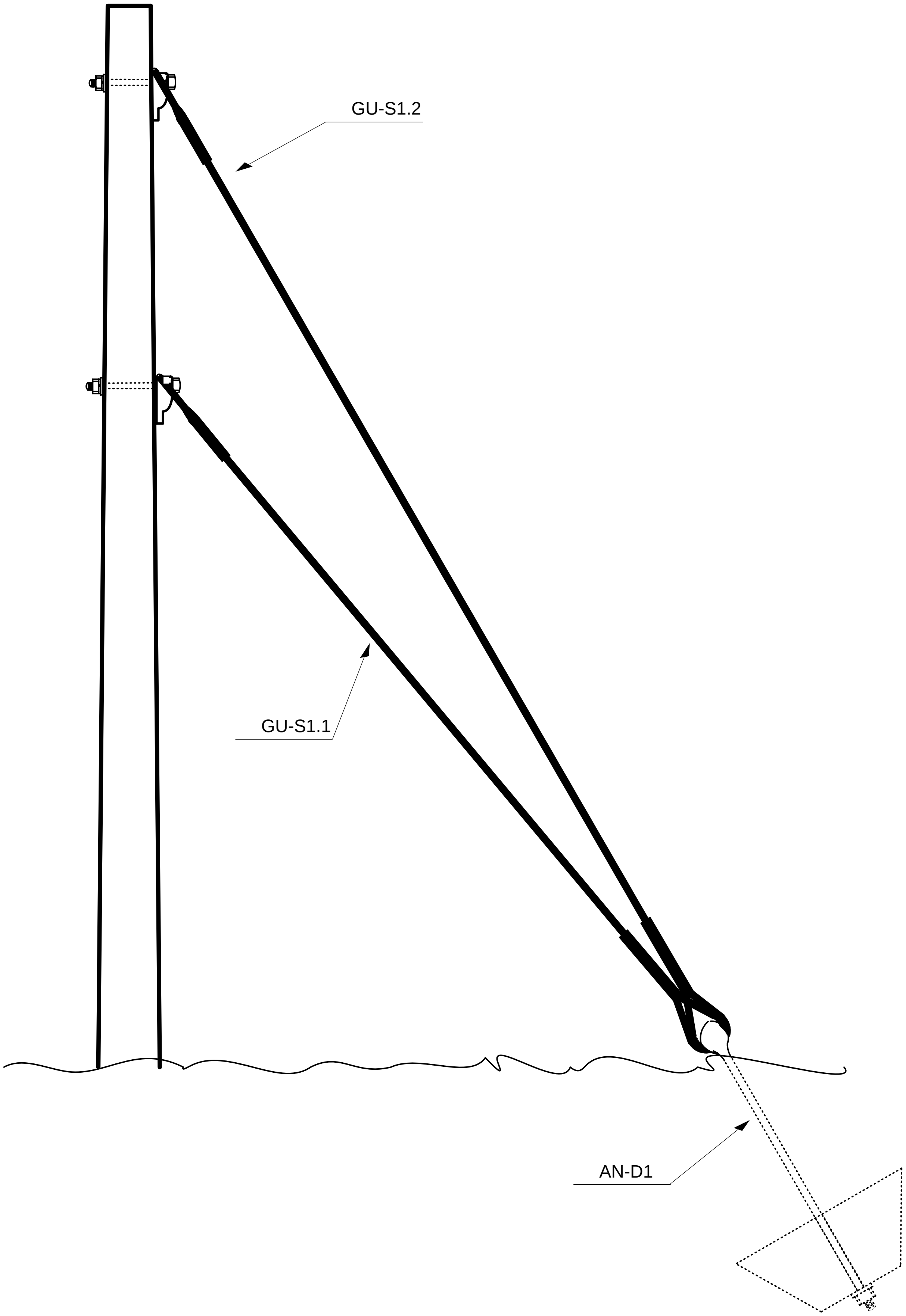
Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single down guy for low voltage			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U — **GU-101C**



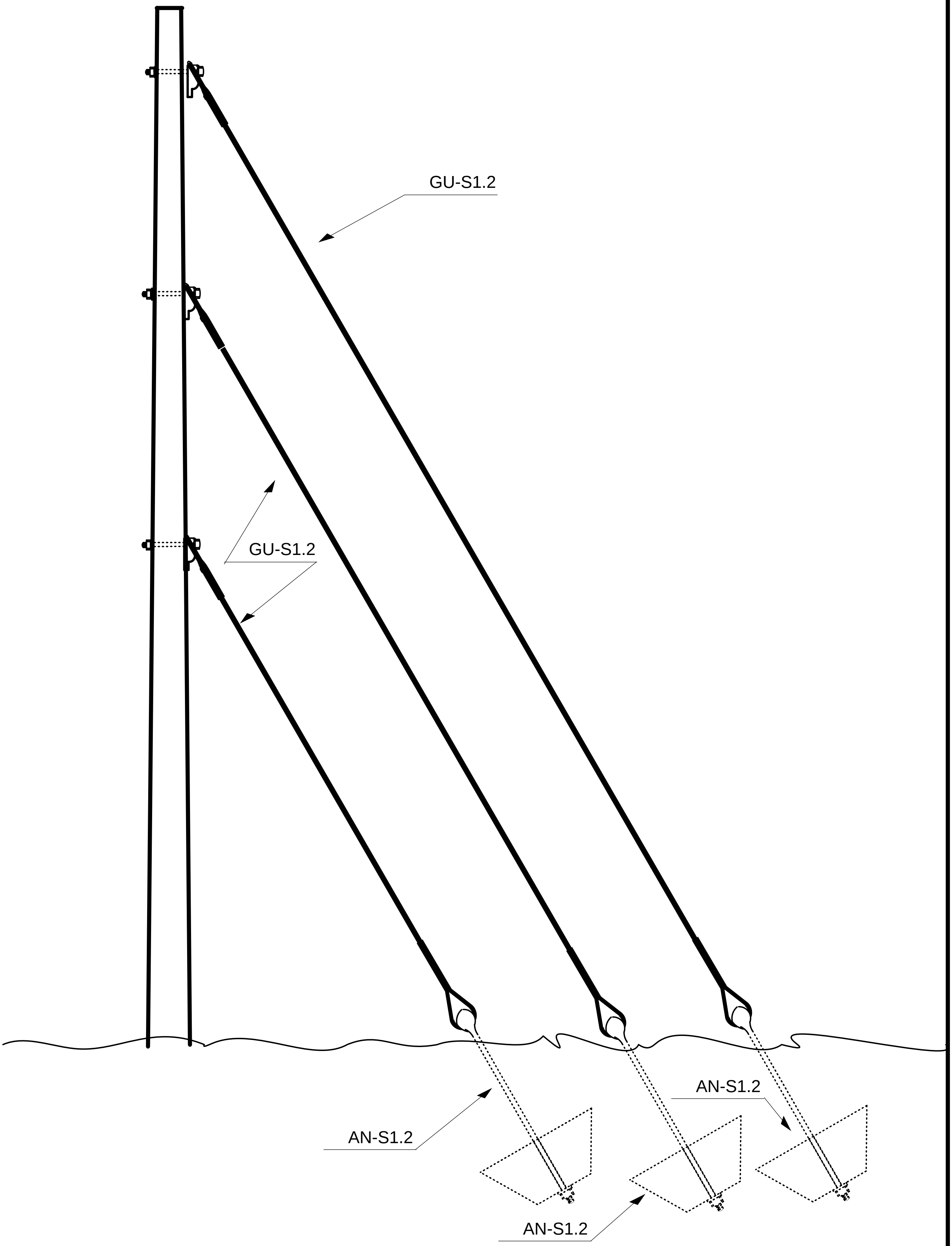
Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Single down guy for medium voltage		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without
		U	**GU-102C**



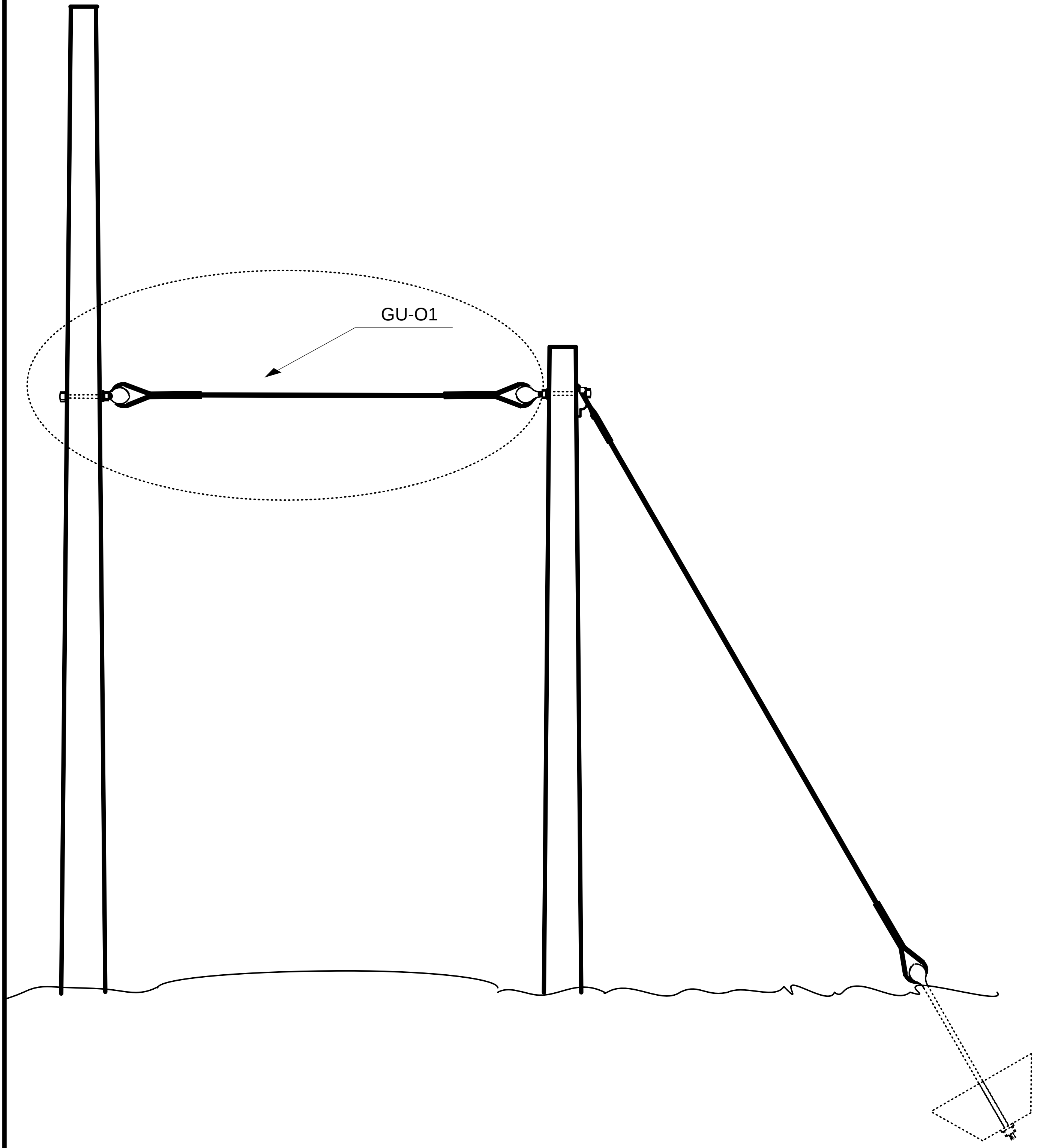
Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Two down guys for LV/MV	Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005 / Revision: 1 / Scale: Without	U / **GU-201C**



Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Two down guys with one anchor		Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U	GU-202C



Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Three down guys for medium voltage	Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005 / Revision: 1 / Scale: Without	U / **GU-301C**



Ministry of Water and Power decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH	Single overhead guy			Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: January, 2005	Revision: 1	Scale: Without	U GU-401C

TABLE OF CABLE AND CONDUCTORS ASSIGNATION

Cables and Conductors	Assigned to
Conductor ACSR 70/12 mm2	MV overhead line
Conductor ACSR 120/20 mm2	MV overhead line
Conductor ACSR 185/30 mm2	MV overhead line
Cable ABC 3 x50 Al + 1 x 70 Alloy	LV overhead line
Cable ABC 3 x95 Al + 1 x 70 Alloy	LV overhead line
Cable ABC 3 x120 Al + 1 x 70 Alloy	LV overhead line
Cable N2XS2Y 1 x 50 RM / 16, 12/20 kv	MV underground
Cable N2XS2Y 1 x 95 RM / 16, 12/20 kV	MV underground
Cable N2XS2Y 1 x 120 RM / 16, 12/20 kV	MV underground
Cable N2XS2Y 1 x 240 RM / 25, 12/20 kV	MV underground
Cable NYCWY 4 x 50 SM / 25 , 0.6/1 kV	LV board (CS, indoor transf.) to Feeder Pillars to meter boxes
Cable NYCWY 4 x 120 SM / 70, 0.6/1 kV	LV board (CS, indoor transf.) to Feeder Pillars to meter boxes
Cable NYCWY 4 x 150 SM / 70, 0.6/1 kV	LV board (CS, indoor transf.) to Feeder Pillars to meter boxes
Cables NYY-J 3 x 4 RE, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cables NYY-J 3 x 6 RE, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cables NYY-J 3 x 10 RE, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cables NYY-J 3 x 16 RE, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cables NYY-J 5 x 10 RE, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cables NYY-J 5 x 16 RE, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cables NYY-J 5 x 25 RM, 0.6/1 kV	Services Cables / Meter boxes to consumers
Cable NYY 1 x 120 RM, 0.6/1 kV	LV neutral transformer to Feeder Pillars
Cable NYY 1 x 240 RM, 0.6/1 kV	LV bushings transformer to Feeder Pillars
Conductor Cu 25 mm2 stranded / soft drawn	Earth system in LV and consumers
Conductor Cu 35 mm2 stranded / soft drawn	Earth system in MV (pole to cross arm, earth rod, etc)
Conductor Cu 35 mm2 stranded / mediun hard drawn	OHL to transformers or capacitors banks

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Table of Cable and Conductors Assignation			Drawing:	
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1	Scale: Without	**U**	**C-001**

Weather case (hypothesis of calculation)

Case	Temperature ºC	Ice thickness (cm)	Wind (km/h)
1. EDS (Every day stress)	25	0.0	0
2. Cold	-10	0.0	0
3. Cold + ice	-10	0.5	0
4. Cold + ice + wind	-10	0.5	40
5. Máx wind	15	0.0	120
6. Hot	40	0.0	0
7. Hot (*)	70	0.0	0

(*) Only for MV

MV overhead line

Conductor ACSR 70/12 mm2
Conductor ACSR 120/20 mm2
Conductor ACSR 185/30 mm2

LV overhead line

Cable ABC 3 x50 Al + 1 x 70 Alloy
Cable ABC 3 x95 Al + 1 x 70 Alloy
Cable ABC 3 x120 Al + 1 x 70 Alloy

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH	Weather case			Drawing:	
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1	Scale: Without	U	**C-002**

(See attached sheets)

Ministry of Energy and Water **decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH**	Medium Voltage Conductors	Drawing:
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004 | Revision: 1.1 | Scale: Without	**U** **C-003**

PLS-CADD Version 5.08L 9:24:21 AM Saturday, January 15, 2005
Decon
Project Name: 'c:\pls\pls_cadd\examples\projects\mv_new_kabul.LOA'

Weather Cases

#	Description	Wind Vel (m/s)	Wind Pres (Pa)	Ice Thick (cm)	Ice Density (daN/dm^3)	Ice Load (daN/m)	Temp (deg C)	Weather Load Factor	NESC Constant (daN/m)	Wind Height Adjust.	Conductor GRF	Structure GRF
1	Kabul 25	0	0.0	0.00	0.000	0.00	25	1.00	0.00	None	1	1
2	kabul -10	0	0.0	0.00	0.000	0.00	-10	1.00	0.00	None	1	1
3	kabul -10 + ice	0	0.0	0.50	0.800	0.00	-10	1.00	0.00	None	1	1
4	kabul -10 + ice	11	75.7	0.50	0.800	0.00	-10	1.00	0.00	None	1	1
5	kabul +15 + win	33	681.0	0.00	0.000	0.00	15	1.00	0.00	None	1	1
6	kabul + 40	0	0.0	0.00	0.000	0.00	40	1.00	0.00	None	1	1
7	kabul +70	0	0.0	0.00	0.000	0.00	70	1.00	0.00	None	1	1

Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120
ASCE terrain category B

Maximum tensions calculated using actual section geometry

Cable Tension Criteria

LC #	WC #	Weather case Description	Cable Condition	Allowable %Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable
1	1	Kabul 25	Initial RS	18.000	0.000	0.000	ALL CABLES
2	5	kabul +15 + win	Load RS	33.000	0.000	0.000	ALL CABLES
3	4	kabul -10 + ice	Load RS	33.000	0.000	0.000	ALL CABLES

Automatic Sagging Criteria

LC #	WC #	Weather case Description	Cable Condition	Allowable %Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable
1	1	Kabul 25	Initial RS	12.000	0.000	0.000	ALL CABLES

Ruling Span Sag Tension Report

Section #1 '185/30'
Cable 'c:\pls\pls_cadd\examples\cables\180-30 acsr', Ruling span (m) 45
Sagging data: Catenary (m) 474.618 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE #	DESCRIPTION	CABLE LOAD HOR. LOAD (daN/m)	CABLE LOAD VERT LOAD (daN/m)	CABLE LOAD RES. LOAD (daN/m)	R.S. INITIAL COND. MAX. TENS. (daN)	R.S. INITIAL COND. HORI. TENS. (daN)	R.S. INITIAL COND. % UL	R.S. INITIAL COND. C (m)	R.S. INITIAL COND. R.S. SAG (m)	R.S. FINAL COND. AFTER CREEP MAX. TENS. (daN)	R.S. FINAL COND. AFTER CREEP HORI. TENS. (daN)	R.S. FINAL COND. AFTER CREEP % UL	R.S. FINAL COND. AFTER CREEP C (m)	R.S. FINAL COND. AFTER CREEP R.S. SAG (m)	R.S. FINAL COND. AFTER LOAD MAX. TENS. (daN)	R.S. FINAL COND. AFTER LOAD HORI. TENS. (daN)	R.S. FINAL COND. AFTER LOAD % UL	R.S. FINAL COND. AFTER LOAD C (m)	R.S. FINAL COND. AFTER LOAD R.S. SAG (m)
1	Kabul 25	0.00	0.73	0.73	345	345	5	475	0.53	345	345	5	475	0.53	345	345	5	475	0.53
2	kabul -10	0.00	0.73	0.73	906	906	14	1247	0.20	906	906	14	1247	0.20	906	906	14	1247	0.20
3	kabul -10 + ice	0.00	1.03	1.03	973	973	15	946	0.27	973	973	15	946	0.27	973	973	15	946	0.27
4	kabul -10 + ice	0.22	1.03	1.05	978	978	15	930	0.27	978	978	15	930	0.27	978	978	15	930	0.27
5	kabul +15 + win	1.29	0.73	1.48	688	687	10	463	0.55	688	687	10	463	0.55	688	687	10	463	0.55
6	kabul + 40	0.00	0.73	0.73	270	270	4	371	0.68	270	270	4	371	0.68	270	270	4	371	0.68
7	kabul +70	0.00	0.73	0.73	199	198	3	273	0.93	199	198	3	273	0.93	199	198	3	273	0.93

Ruling Span Sag Tension Report

Section #2 '120/20'
Cable 'c:\pls\pls_cadd\examples\cables\120-20 acsr', Ruling span (m) 45
Sagging data: Catenary (m) 620.347 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE #	DESCRIPTION	CABLE LOAD HOR. LOAD (daN/m)	CABLE LOAD VERT LOAD (daN/m)	CABLE LOAD RES. LOAD (daN/m)	R.S. INITIAL COND. MAX. TENS. (daN)	R.S. INITIAL COND. HORI. TENS. (daN)	R.S. INITIAL COND. % UL	R.S. INITIAL COND. C (m)	R.S. INITIAL COND. R.S. SAG (m)	R.S. FINAL COND. AFTER CREEP MAX. TENS. (daN)	R.S. FINAL COND. AFTER CREEP HORI. TENS. (daN)	R.S. FINAL COND. AFTER CREEP % UL	R.S. FINAL COND. AFTER CREEP C (m)	R.S. FINAL COND. AFTER CREEP R.S. SAG (m)	R.S. FINAL COND. AFTER LOAD MAX. TENS. (daN)	R.S. FINAL COND. AFTER LOAD HORI. TENS. (daN)	R.S. FINAL COND. AFTER LOAD % UL	R.S. FINAL COND. AFTER LOAD C (m)	R.S. FINAL COND. AFTER LOAD R.S. SAG (m)
1	Kabul 25	0.00	0.48	0.48	300	300	7	620	0.41	300	300	7	620	0.41	300	300	7	620	0.41
2	kabul -10	0.00	0.48	0.48	814	814	18	1683	0.15	814	814	18	1683	0.15	814	814	18	1683	0.15
3	kabul -10 + ice	0.00	0.74	0.74	852	851	19	1149	0.22	852	851	19	1149	0.22	852	851	19	1149	0.22
4	kabul -10 + ice	0.19	0.74	0.77	855	855	19	1116	0.23	855	855	19	1116	0.23	855	855	19	1116	0.23
5	kabul +15 + win	1.06	0.48	1.16	606	605	13	521	0.49	606	605	13	521	0.49	606	605	13	521	0.49
6	kabul + 40	0.00	0.48	0.48	216	215	5	445	0.57	216	215	5	445	0.57	216	215	5	445	0.57
7	kabul +70	0.00	0.48	0.48	146	146	3	301	0.84	146	146	3	301	0.84	146	146	3	301	0.84

Ruling Span Sag Tension Report

Section #3 '70/12'
Cable 'c:\pls\pls_cadd\examples\cables\70-12 acsr', Ruling span (m) 45
Sagging data: Catenary (m) 717.875 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE		CABLE LOAD			R.S. INITIAL COND.					R.S. FINAL COND. AFTER CREEP					R.S. FINAL COND. AFTER LOAD				
#	DESCRIPTION	HOR. LOAD (daN/m)	VERT LOAD (daN/m)	RES. LOAD (daN/m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)
1	Kabul 25	0.00	0.28	0.28	201	200	7	719	0.35	201	200	7	719	0.35	201	200	7	719	0.35
2	kabul -10	0.00	0.28	0.28	527	527	20	1890	0.13	527	527	20	1890	0.13	527	527	20	1890	0.13
3	kabul -10 + ice	0.00	0.49	0.49	553	553	21	1132	0.22	553	553	21	1132	0.22	553	553	21	1132	0.22
4	kabul -10 + ice	0.16	0.49	0.52	557	557	21	1081	0.23	557	557	21	1081	0.23	557	557	21	1081	0.23
5	kabul +15 + win	0.80	0.28	0.84	425	425	16	503	0.50	425	425	16	503	0.50	425	425	16	503	0.50
6	kabul + 40	0.00	0.28	0.28	138	137	5	493	0.51	138	137	5	493	0.51	138	137	5	493	0.51
7	kabul +70	0.00	0.28	0.28	89	88	3	318	0.80	89	88	3	318	0.80	89	88	3	318	0.80

Ruling Span Sag Tension Report

Section #4 '185/30'
Cable 'c:\pls\pls_cadd\examples\cables\180-30 acsr', Ruling span (m) 60
Sagging data: Catenary (m) 819.92 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE		CABLE LOAD			R.S. INITIAL COND.					R.S. FINAL COND. AFTER CREEP					R.S. FINAL COND. AFTER LOAD				
#	DESCRIPTION	HOR. LOAD (daN/m)	VERT LOAD (daN/m)	RES. LOAD (daN/m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)
1	Kabul 25	0.00	0.73	0.73	596	596	9	820	0.55	596	596	9	820	0.55	596	596	9	820	0.55
2	kabul -10	0.00	0.73	0.73	1386	1386	21	1907	0.24	1386	1386	21	1907	0.24	1386	1386	21	1907	0.24
3	kabul -10 + ice	0.00	1.03	1.03	1443	1443	22	1403	0.32	1443	1443	22	1403	0.32	1443	1443	22	1403	0.32
4	kabul -10 + ice	0.22	1.03	1.05	1448	1448	22	1377	0.33	1448	1448	22	1377	0.33	1448	1448	22	1377	0.33
5	kabul +15 + win	1.29	0.73	1.48	1042	1041	16	702	0.64	1042	1041	16	702	0.64	1042	1041	16	702	0.64
6	kabul + 40	0.00	0.73	0.73	440	439	7	604	0.74	440	439	7	604	0.74	440	439	7	604	0.74
7	kabul +70	0.00	0.73	0.73	299	298	5	410	1.10	299	298	5	410	1.10	299	298	5	410	1.10

Ruling Span Sag Tension Report

Section #5 '120/20'
Cable 'c:\pls\pls_cadd\examples\cables\120-20 acsr', Ruling span (m) 60
Sagging data: Catenary (m) 847.808 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE #	DESCRIPTION	CABLE LOAD HOR. LOAD (daN/m)	CABLE LOAD VERT LOAD (daN/m)	CABLE LOAD RES. LOAD (daN/m)	R.S. INITIAL COND. MAX. TENS. (daN)	R.S. INITIAL COND. HORI. TENS. (daN)	R.S. INITIAL COND. % UL	R.S. INITIAL COND. C (m)	R.S. INITIAL COND. R.S. SAG (m)	R.S. FINAL COND. AFTER CREEP MAX. TENS. (daN)	AFTER CREEP HORI. TENS. (daN)	AFTER CREEP % UL	AFTER CREEP C (m)	AFTER CREEP R.S. SAG (m)	R.S. FINAL COND. AFTER LOAD MAX. TENS. (daN)	AFTER LOAD HORI. TENS. (daN)	AFTER LOAD % UL	AFTER LOAD C (m)	AFTER LOAD R.S. SAG (m)
1	Kabul 25	0.00	0.48	0.48	410	410	9	847	0.53	410	410	9	847	0.53	410	410	9	847	0.53
2	kabul -10	0.00	0.48	0.48	947	947	21	1957	0.23	947	947	21	1957	0.23	947	947	21	1957	0.23
3	kabul -10 + ice	0.00	0.74	0.74	994	994	22	1341	0.34	994	994	22	1341	0.34	994	994	22	1341	0.34
4	kabul -10 + ice	0.19	0.74	0.77	999	999	22	1304	0.34	999	999	22	1304	0.34	999	999	22	1304	0.34
5	kabul +15 + win	1.06	0.48	1.16	766	765	17	659	0.68	766	765	17	659	0.68	766	765	17	659	0.68
6	kabul + 40	0.00	0.48	0.48	300	300	7	620	0.73	300	300	7	620	0.73	300	300	7	620	0.73
7	kabul +70	0.00	0.48	0.48	202	201	4	416	1.08	202	201	4	416	1.08	202	201	4	416	1.08

Ruling Span Sag Tension Report

Section #6 '70/12'
Cable 'c:\pls\pls_cadd\examples\cables\70-12 acsr', Ruling span (m) 60
Sagging data: Catenary (m) 865.039 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE #	DESCRIPTION	CABLE LOAD HOR. LOAD (daN/m)	CABLE LOAD VERT LOAD (daN/m)	CABLE LOAD RES. LOAD (daN/m)	R.S. INITIAL COND. MAX. TENS. (daN)	R.S. INITIAL COND. HORI. TENS. (daN)	R.S. INITIAL COND. % UL	R.S. INITIAL COND. C (m)	R.S. INITIAL COND. R.S. SAG (m)	R.S. FINAL COND. AFTER CREEP MAX. TENS. (daN)	AFTER CREEP HORI. TENS. (daN)	AFTER CREEP % UL	AFTER CREEP C (m)	AFTER CREEP R.S. SAG (m)	R.S. FINAL COND. AFTER LOAD MAX. TENS. (daN)	AFTER LOAD HORI. TENS. (daN)	AFTER LOAD % UL	AFTER LOAD C (m)	AFTER LOAD R.S. SAG (m)
1	Kabul 25	0.00	0.28	0.28	241	241	9	865	0.52	241	241	9	865	0.52	241	241	9	865	0.52
2	kabul -10	0.00	0.28	0.28	554	554	21	1988	0.23	554	554	21	1988	0.23	554	554	21	1988	0.23
3	kabul -10 + ice	0.00	0.49	0.49	594	594	22	1216	0.37	594	594	22	1216	0.37	594	594	22	1216	0.37
4	kabul -10 + ice	0.16	0.49	0.52	599	599	22	1162	0.39	599	599	22	1162	0.39	599	599	22	1162	0.39
5	kabul +15 + win	0.80	0.28	0.84	502	501	19	593	0.76	502	501	19	593	0.76	502	501	19	593	0.76
6	kabul + 40	0.00	0.28	0.28	176	175	7	629	0.72	176	175	7	629	0.72	176	175	7	629	0.72
7	kabul +70	0.00	0.28	0.28	117	117	4	419	1.07	117	117	4	419	1.07	117	117	4	419	1.07

Check Section Report

Section #1 '185/30'
Cable 'c:\pls\pls_cadd\examples\cables\180-30 acsr', Ruling span (m) 45
Sagging data: Catenary (m) 474.618 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC #	WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY	
1	Kabul 25	Initial RS	18.0	5.2	NA	345.3	NA	474.5	29.0	OK
5	kabul +15 + win	Load RS	33.0	10.4	NA	687.8	NA	462.9	31.5	OK
4	kabul -10 + ice	Load RS	33.0	14.8	NA	978.3	NA	930.0	44.8	OK

Check Section Report

Section #2 '120/20'
Cable 'c:\pls\pls_cadd\examples\cables\120-20 acsr', Ruling span (m) 45
Sagging data: Catenary (m) 620.347 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC #	WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY	
1	Kabul 25	Initial RS	18.0	6.6	NA	299.9	NA	619.8	36.5	OK
5	kabul +15 + win	Load RS	33.0	13.3	NA	605.7	NA	521.2	40.2	OK
4	kabul -10 + ice	Load RS	33.0	18.7	NA	854.9	NA	1116.0	56.7	OK

Check Section Report

Section #3 '70/12'
Cable 'c:\pls\pls_cadd\examples\cables\70-12 acsr', Ruling span (m) 45
Sagging data: Catenary (m) 717.875 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC #	WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY	
1	Kabul 25	Initial RS	18.0	7.5	NA	200.5	NA	719.4	41.6	OK

5 kabul +15 + win	Load RS	33.0	15.9	NA	425.0	NA	503.0	48.1 OK
4 kabul -10 + ice	Load RS	33.0	20.8	NA	557.0	NA	1080.7	63.0 OK

Check Section Report

Section #4 '185/30'
Cable 'c:\pls\pls_cadd\examples\cables\180-30 acsr', Ruling span (m) 60
Sagging data: Catenary (m) 819.92 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC # WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY
1 Kabul 25	Initial RS	18.0	9.0	NA	596.3	NA	819.7	50.0 OK
5 kabul +15 + win	Load RS	33.0	15.7	NA	1042.4	NA	701.5	47.7 OK
4 kabul -10 + ice	Load RS	33.0	21.9	NA	1448.2	NA	1376.6	66.3 OK

Check Section Report

Section #5 '120/20'
Cable 'c:\pls\pls_cadd\examples\cables\120-20 acsr', Ruling span (m) 60
Sagging data: Catenary (m) 847.808 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC # WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY
1 Kabul 25	Initial RS	18.0	9.0	NA	410.1	NA	847.2	49.9 OK
5 kabul +15 + win	Load RS	33.0	16.8	NA	765.8	NA	658.7	50.8 OK
4 kabul -10 + ice	Load RS	33.0	21.9	NA	999.5	NA	1304.5	66.3 OK

Check Section Report

Section #6 '70/12'
Cable 'c:\pls\pls_cadd\examples\cables\70-12 acsr', Ruling span (m) 60
Sagging data: Catenary (m) 865.039 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC #	WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY	
1	Kabul 25	Initial RS	18.0	9.0	NA	241.1	NA	864.8	50.0	OK
5	kabul +15 + win	Load RS	33.0	18.7	NA	501.5	NA	593.2	56.7	OK
4	kabul -10 + ice	Load RS	33.0	22.4	NA	599.1	NA	1162.1	67.7	OK

(See attached sheets)

Ministry of Energy and Water decon DEUTSCHE ENERGIE-CONSULT INGENIEURGESELLSCHAFT mbH MWP	Low Voltage Cable			Drawing:	
Rehabilitation and Extension of Kabul City Distribution Network	Date: December 2004	Revision: 1.1	Scale: Without	**U**	**C-004**

PLS-CADD Version 5.08L 9:31:36 AM Saturday, January 15, 2005
Decon
Project Name: 'c:\pls\pls_cadd\examples\projects\new lv-kabul.CRI'

Weather Cases

#	Description	Wind Vel (m/s)	Wind Pres (Pa)	Ice Thick (cm)	Ice Density (daN/dm^3)	Ice Load (daN/m)	Temp (deg C)	Weather Load Factor	NESC Constant (daN/m)	Wind Height Adjust.	Conductor GRF	Structure GRF
1	Kabul 25	0	0.0	0.00	0.000	0.00	25	1.00	0.00	None	1	1
2	kabul -10	0	0.0	0.00	0.000	0.00	-10	1.00	0.00	None	1	1
3	kabul -10 + ice	0	0.0	0.50	0.800	0.00	-10	1.00	0.00	None	1	1
4	kabul -10 + ice	11	75.7	0.50	0.800	0.00	-10	1.00	0.00	None	1	1
5	kabul +15 + win	33	681.0	0.00	0.000	0.00	15	1.00	0.00	None	1	1
6	kabul + 40	0	0.0	0.00	0.000	0.00	40	1.00	0.00	None	1	1

Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120
ASCE terrain category B

Maximum tensions calculated using actual section geometry

Cable Tension Criteria

LC #	WC #	Weather case Description	Cable Condition	Allowable %Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable
1	1	Kabul 25	Initial RS	18.000	0.000	0.000	ALL CABLES
2	5	kabul +15 + win	Load RS	33.000	0.000	0.000	ALL CABLES
3	4	kabul -10 + ice	Load RS	33.000	0.000	0.000	ALL CABLES

Automatic Sagging Criteria

LC #	WC #	Weather case Description	Cable Condition	Allowable %Ultimate	Maximum Tension (daN)	Maximum Catenary (m)	Applicable Cable
1	1	Kabul 25	Initial RS	12.000	0.000	0.000	ALL CABLES

Ruling Span Sag Tension Report

Section #1 'LV 4/0 Quadruplex'
Cable 'c:\pls\pls_cadd\examples\cables\cables_library\multiplex\appaloosa_xlp_quadruplex.wir', Ruling span (m) 45
Sagging data: Catenary (m) 322.304 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE		CABLE LOAD (daN/m)			R.S. INITIAL COND.					R.S. FINAL COND. AFTER CREEP					R.S. FINAL COND. AFTER LOAD				
#	DESCRIPTION	HOR. LOAD	VERT LOAD	RES. LOAD	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)
1	Kabul 25	0.00	1.55	1.55	501	500	13	322	0.79	451	450	12	290	0.87	478	477	13	307	0.82
2	kabul -10	0.00	1.55	1.55	692	691	19	445	0.57	626	625	17	403	0.63	682	681	18	439	0.58
3	kabul -10 + ice	0.00	2.09	2.09	803	802	22	384	0.66	754	753	20	360	0.70	803	802	22	384	0.66
4	kabul -10 + ice	0.36	2.09	2.12	809	808	22	381	0.66	761	760	20	358	0.71	809	808	22	381	0.66
5	kabul +15 + win	2.58	1.55	3.01	845	842	23	280	0.91	808	805	22	268	0.95	845	842	23	280	0.91
6	kabul + 40	0.00	1.55	1.55	448	446	12	288	0.88	406	404	11	261	0.97	427	425	11	274	0.92

WEATHER CASE DESCRIPTION		INITIAL CONDITION HORIZ. TENSION (daN)			FINAL AFTER CREEP HORIZ. TENSION (daN)			FINAL AFTER LOAD HORIZ. TENSION (daN)		
		TOTAL	CORE	OUTER	TOTAL	CORE	OUTER	TOTAL	CORE	OUTER
1	Kabul 25	500	223	277	450	286	163	477	244	233
2	kabul -10	691	228	463	625	258	366	681	226	455
3	kabul -10 + ice	802	277	524	753	304	449	802	277	524
4	kabul -10 + ice	808	280	528	760	306	453	808	280	528
5	kabul +15 + win	842	348	494	805	387	418	842	348	494
6	kabul + 40	446	234	212	404	309	95	425	264	161

Ruling Span Sag Tension Report

Section #2 'LV 4/0 Quadruplex'
Cable 'c:\pls\pls_cadd\examples\cables\cables_library\multiplex\appaloosa_xlp_quadruplex.wir', Ruling span (m) 40
Sagging data: Catenary (m) 322.304 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

WEATHER CASE		CABLE LOAD			R.S. INITIAL COND.					R.S. FINAL COND. AFTER CREEP					R.S. FINAL COND. AFTER LOAD				
#	DESCRIPTION	HOR. LOAD (daN/m)	VERT LOAD (daN/m)	RES. LOAD (daN/m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)	MAX. TENS. (daN)	HORI. TENS. (daN)	% UL	C (m)	R.S. SAG (m)
1	Kabul 25	0.00	1.55	1.55	501	500	13	322	0.62	443	442	12	285	0.70	475	474	13	306	0.65
2	kabul -10	0.00	1.55	1.55	728	728	20	469	0.43	656	655	18	422	0.47	725	724	20	467	0.43
3	kabul -10 + ice	0.00	2.09	2.09	824	822	22	394	0.51	771	770	21	368	0.54	824	822	22	394	0.51
4	kabul -10 + ice	0.36	2.09	2.12	829	828	22	390	0.51	777	776	21	366	0.55	829	828	22	390	0.51
5	kabul +15 + win	2.58	1.55	3.01	829	826	22	275	0.73	787	784	21	261	0.77	829	826	22	275	0.73
6	kabul + 40	0.00	1.55	1.55	439	437	12	282	0.71	392	391	11	252	0.79	415	414	11	267	0.75

WEATHER CASE DESCRIPTION	INITIAL CONDITION HORIZ. TENSION (daN) TOTAL	CORE	OUTER	FINAL AFTER CREEP HORIZ. TENSION (daN) TOTAL	CORE	OUTER	FINAL AFTER LOAD HORIZ. TENSION (daN) TOTAL	CORE	OUTER
1 Kabul 25	500	223	277	442	282	160	474	242	232
2 kabul -10	728	244	483	655	267	387	724	240	484
3 kabul -10 + ice	822	287	536	770	308	462	822	287	536
4 kabul -10 + ice	828	289	539	776	310	465	828	289	539
5 kabul +15 + win	826	341	485	784	378	406	826	341	485
6 kabul + 40	437	231	207	391	302	88	414	259	155

Ruling Span Sag Tension Report

Section #3 'LV 4/0 Quadruplex'
Cable 'c:\pls\pls_cadd\examples\cables\cables_library\multiplex\appaloosa_xlp_quadruplex.wir', Ruling span (m) 35
Sagging data: Catenary (m) 322.304 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

#	WEATHER CASE DESCRIPTION	CABLE LOAD HOR. LOAD (daN/m)	CABLE LOAD VERT LOAD (daN/m)	CABLE LOAD RES. LOAD (daN/m)	R.S. INITIAL COND. MAX. TENS. (daN)	R.S. INITIAL COND. HORI. TENS. (daN)	R.S. INITIAL COND. % UL	R.S. INITIAL COND. C (m)	R.S. INITIAL COND. R.S. SAG (m)	R.S. FINAL COND. AFTER CREEP MAX. TENS. (daN)	R.S. FINAL COND. AFTER CREEP HORI. TENS. (daN)	R.S. FINAL COND. AFTER CREEP % UL	R.S. FINAL COND. AFTER CREEP C (m)	R.S. FINAL COND. AFTER CREEP R.S. SAG (m)	R.S. FINAL COND. AFTER LOAD MAX. TENS. (daN)	R.S. FINAL COND. AFTER LOAD HORI. TENS. (daN)	R.S. FINAL COND. AFTER LOAD % UL	R.S. FINAL COND. AFTER LOAD C (m)	R.S. FINAL COND. AFTER LOAD R.S. SAG (m)
1	Kabul 25	0.00	1.55	1.55	501	500	13	322	0.48	434	433	12	279	0.55	472	470	13	303	0.51
2	kabul -10	0.00	1.55	1.55	769	768	21	495	0.31	693	692	19	446	0.34	769	768	21	495	0.31
3	kabul -10 + ice	0.00	2.09	2.09	846	844	23	404	0.38	792	790	21	378	0.40	846	844	23	404	0.38
4	kabul -10 + ice	0.36	2.09	2.12	850	849	23	400	0.38	797	796	21	375	0.41	850	849	23	400	0.38
5	kabul +15 + win	2.58	1.55	3.01	810	807	22	268	0.57	763	760	21	253	0.61	810	807	22	268	0.57
6	kabul + 40	0.00	1.55	1.55	428	426	12	275	0.56	375	374	10	241	0.64	402	400	11	258	0.59

#	WEATHER CASE DESCRIPTION	INITIAL CONDITION HORIZ. TENSION (daN) TOTAL	INITIAL CONDITION CORE	INITIAL CONDITION OUTER	FINAL AFTER CREEP HORIZ. TENSION (daN) TOTAL	FINAL AFTER CREEP CORE	FINAL AFTER CREEP OUTER	FINAL AFTER LOAD HORIZ. TENSION (daN) TOTAL	FINAL AFTER LOAD CORE	FINAL AFTER LOAD OUTER
1	Kabul 25	500	223	277	433	277	156	470	239	232
2	kabul -10	768	262	506	692	279	414	768	262	506
3	kabul -10 + ice	844	297	548	790	313	477	844	297	548
4	kabul -10 + ice	849	299	550	796	315	480	849	299	550
5	kabul +15 + win	807	332	474	760	367	393	807	332	474
6	kabul + 40	426	226	200	374	294	79	400	252	148

Check Section Report

Section #1 'LV 4/0 Quadruplex'
Cable 'c:\pls\pls_cadd\examples\cables\cables_library\multiplex\appaloosa_xlp_quadruplex.wir', Ruling span (m) 45
Sagging data: Catenary (m) 322.304 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC #	WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY	
1	Kabul 25	Initial RS	18.0	13.5	NA	501.3	NA	322.4	75.0	OK
5	kabul +15 + win	Load RS	33.0	22.7	NA	844.5	NA	279.8	68.9	OK
4	kabul -10 + ice	Load RS	33.0	21.8	NA	809.3	NA	380.9	66.0	OK

Check Section Report

Section #2 'LV 4/0 Quadruplex'
Cable 'c:\pls\pls_cadd\examples\cables\cables_library\multiplex\appaloosa_xlp_quadruplex.wir', Ruling span (m) 40
Sagging data: Catenary (m) 322.304 Condition I Temperature (deg C) 25
Weather case for final after creep Kabul 25
Weather case for final after load kabul +15 + wind 120

LC #	WEATHER CASE DESCRIPTION	CONDITION	ALLOWABLE % OF ULTIMATE	ACTUAL % OF ULTIMATE	ALLOWABLE TENSION (daN)	ACTUAL TENSION (daN)	ALLOWABLE CATENARY (m)	ACTUAL CATENARY (m)	% OF ALLOWABLE CAPACITY	
1	Kabul 25	Initial RS	18.0	13.5	NA	501.4	NA	322.4	75.0	OK
5	kabul +15 + win	Load RS	33.0	22.3	NA	829.1	NA	274.7	67.6	OK
4	kabul -10 + ice	Load RS	33.0	22.3	NA	829.0	NA	390.2	67.6	OK

Appendix B

Medium and Low Voltage Distribution Network Standard Technical Specifications

D

CHAPTER A	–	General Project Information
CHAPTER B	–	General Project Specifications
CHAPTER C	–	Medium And Low Voltage Underground Cables And Accessories
CHAPTER D	–	Fiber optic Cables (not included)
CHAPTER E	–	OHL ACSR Conductors and accessories
CHAPTER F	–	ABC Low Voltage Cables And Accessories
CHAPTER G	–	Three Phase Distribution Transformers
CHAPTER H	–	Compact And Indoor Substations
CHAPTER I	–	Junction Stations (Not Included)
CHAPTER J	–	Load Break Switch
CHAPTER K	–	Medium Voltage Disconnecting Switches

CHAPTER A

General Project Information

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CHAPTER A: GENERAL PROJECT INFORMATION

1. GENERAL CONSIDERATIONS

1.1 STRUCTURE OF THE TECHNICAL SPECIFICATIONS

The technical specifications presented in this Section VI of the bidding documents are divided into 25 chapters with letter designations A to Y.

In alphabetical order, the Bidder will find all general information applicable to the entire project in Chapters A and B.

Chapters A and B define the Contractors responsibilities and are valid for all phases of the project and are not repeated in other chapters of these technical specifications, except that landmine related risks are expanded in Chapter X and frequently reference is made to the general technical specifications of Chapter B on electrical design data, system parameters, working conditions, climatic conditions, safety factors and others.

Chapter A Section 4.7 also provides for a minimum level of Training.

Chapters C to T provide specifications for key items to be supplied and to related works.

Chapters C, D, E and F refer to Medium Voltage (MV) and Low Voltage (LV) underground cables, service cables, OHL conductors including MV covered conductors and LV aerial bundled cables (ABC) along with all accessories.

In Chapter G the platform/pole mounted, rail mounted indoor and outdoor distribution transformers are specified.

Chapter H describes the supply of compact station type transformer stations with MV, transformer and LV compartments including three way RMU's. It also covers indoor transformer substation installations protected via RMU, indoor load break switch & fuse and outdoor pole mounted fuse cutouts.

Equipment specified in Chapters J to R refer to overhead line installations partially pole mounted, base-mounted and wall-mounted like load-break switches, fuse cut-outs, Low Voltage Distribution Boards, single phase energy meters, surge arresters and insulators.

Chapter S deals with the fabrication and supply of pre-stressed steel-concrete poles.

The above plant and equipment, with installation works, are specified with the required tests mainly based on IEC Standards.

Chapter T provides for mandatory supply of spare parts, tools and equipment to allow for a three year operation and maintenance period.

Further recommended spare parts by the Contractor (Manufacturer) are to be specified by the Bidder in Schedule of Prices No. 6 of Section VI.

In Chapter U, a minimum of required distribution standards is presented, enabling the Bidder to quote working unit prices in the price schedules No. 4 of Section VI and visualize the arrangements of OHL and underground installations.

In Chapter V the works of OHL and underground installations, indoor type transformer stations including related civil works are specified, with precise scope of works defined in the text.

Chapter W defines certain rules related to the management of the Contractor's warehouse taking into consideration the extensive quantities and different types of supplied plant, equipment and materials, its verification of quality and quantities by the Employer's supervision personnel and its storage along with dismantled materials.

Chapter X details World Bank specified criteria in environmental and social impact management and expands on de-mining processes.

Chapter Y provides the technical data sheets that all bidders must complete thoroughly detailing the offered, guaranteed data of all supplies related to equipment specified in Chapters C to S.

For easier understanding of the technical specification structure, the above mentioned alphabetical letter assignation was chosen and applied as following:

Example letter S: Poles

- Specifications for supply are defined Chapter S
- Technical data sheets for supply are specified in Chapter Y, Tables S
- Prices for supply and works are defined in the schedule of prices, Section VII, items S.

These letter assignations, thoroughly applied in the present bidding documents should facilitate the preparation of the Bidder's bid.

1.2 CONTENTS AND TYPE OF CONTRACT

The Contract for the present Dasht-i-Barchi Distribution Project includes but is not limited to the following main activities:

- Design, supply and installation of MV and LV distribution network in Dasht-i-Barchi and surrounding areas;
- Survey the area of work, prepare designs for MV and LV distribution network in Dast-i-Barchi and surrounding areas;
- Confirm designed bill of quantities of materials and equipment required;
- Prepare a procurement plan for all necessary materials and equipment;
- Supply and installation of outdoor platform/pole-mounted distribution transformers and indoor distribution transformer stations of 100, 160, 250, 400, 630kVA 15(20)/0.4kV;
- Supply and installation of ACSR OHL conductors for MV distribution lines including all fittings attachments;
- Supply and installation of MV cables including all accessories and consumables;
- Supply and installation of three/single-core LV underground cables between 50 mm^2 to 240mm^2 including all accessories and consumables;
- Supply and installation of three/single-core LV underground/overhead service cables between 6 mm^2 to 25mm^2 including all accessories and consumables;
- Supply and installation of LV aerial bundled cables together with all accessories for extension of LV networks;
- Supply and erection of pre-stressed spun concrete poles for MV and LV overhead lines including all fittings and attachements;
- Supply and installation of supplied equipment such as Drop-out Fuses, Disconnectors, distribution transformers, surge arresters, LV distribution boards etc;
- Supply and installation of cable terminations to overhead lines with single pole structures including 12/20 kV 1C cables for connecting indoor and platform mounted transformers;
- Supply and installation of cable terminations to overhead lines with single pole structures including 12/20 kV 1C cables for connecting indoor and platform mounted transformers;
- Spare parts for three years operation and maintenance;
- Training for all types of installation, operation and maintenance activities.

It is possible that some of the removed transformers may contain PCB's. The Contractor shall ensure that its employees wear proper PPE (personal protective equipment) when handling potentially PCB contaminated equipment. The Employer has arranged for PCB testing through another contract and will provide a separate area for storage of potentially contaminated equipment.

The Contract is designed as a turnkey project on unit price basis where individual supply and work unit quantities might fluctuate during the project execution period.

The quantities given in the schedules of prices are estimated and provisional and are given to provide a common basis for bidding. The basis of payment will be the actual quantities of works ordered and carried out, as measured by the Contractor and verified by the Project Manager and valued at the rates and prices stipulated in the schedules of prices.

Actual quantities are nominated in the relevant Schedules of Prices.

1.3 De-Mining and Removal of Unexploded Ordnance (UXO's)

It is understood that the project area is free of unexploded ordnance and mines; nevertheless, the Contractor will be responsible for mine related risks. A provisional sum for mine actions is incorporated in the price schedules of Section VII, which may or may not be expended during the project works.

Section VII Chapter X expands on de-mining criteria, however is summarized herewith.

De-mining and removal of UXO's will be carried out by approved subcontractors employed by the main Contractor, specialized in such works and accredited by UNMACA (United Nations Mine Action Center for Afghanistan).

The Contractor shall assume total and complete responsibility for the scheduling of personnel and equipment in areas required to be de-mined. Any and all areas required for traffic diversions or by-passes shall be specifically established. The Contractor shall as his first priority establish a senior member of his organization to meet and coordinate with UNMACA on all requirements for the removal of land mines and unexploded ordnance. UNMACA will act as Quality Assurance agent.

The Contractor shall submit a program of de-mining works separately and this shall complement the overall program of works.

No personnel or equipment shall be permitted in any area until such time as the area has been certified to be free from mines and UXO's.

2. DESCRIPTION OF EXISTING SYSTEM

2.1 STATUS OF THE DISTRIBUTION SYSTEM

In the following a short description of the present distribution system is given for illustrative purposes of the actual status.

15 KV distributor feeders originate from the grid substations, primary substation and the junction stations feeding various parts of the city. The 15 kV distribution network consists of lines both overhead and underground. The central part of the city and a few other areas are fed via underground distribution networks. In other areas the distribution network is primarily overhead.

The existing LV distribution system consists of both overhead and underground networks. The consumer service connections are provided though pole mounted or pedestal mounted meter boxes.

The Kabul Electricity Authority, DABS, is experiencing major difficulties in maintaining the grid substations due to lack of spare parts.

The majority of the existing medium and low voltage electricity distribution networks and consumer supply connections in Kabul are in a dilapidated condition and extensive rehabilitation or replacement is required. The existing status of the networks has been caused due to various reasons such as destruction during disturbances, lack of proper maintenance, lack of spare parts, effects of aging and absence of adequate investment to maintain and upgrade the networks.

The reliability of electricity supply is at very low level due to load shedding as well as due to the frequent failures of the distribution network. The existing distribution system is also constrained by inadequate capacity of the network components such as power lines, cables, transformers. This has caused excessive voltage drops in most parts of the network causing severe difficulties to the consumers. It has also prevented new consumers being added to the network, who are waiting for supply connection for a long time.

The present condition of the network also poses a serious safety hazard to the general public, as well as to the operational (DABS) staff due to exposed or unprotected live network components, inadequate clearances.

The Ministry of Energy and Water intends to correct the poor state of the distribution system by rehabilitating and extending the distribution networks, to appropriate standards incorporating best practices, with economical designs to maximize the return on the investment.

The objective of the project is to implement the measures identified by the Consultants together with the MEW & DABS for rehabilitation of the distribution networks, to ensure provision of reliable electricity supply to the City whilst ensuring an appropriate economic return on the investment.

2.2 NETWORK SURVEY

During the implementation stage, it would be the responsibility of the Contractor to complete survey and provide necessary information including the as-built drawings/route drawings. This information shall be updated/incorporated into the GIS database for handing over to the MEW at the completion of the project.

3. REHABILITATION MEASURES

The network rehabilitation/expansion works are designed to upgrade and reinforce the distribution networks to address existing capacity constraints, voltage drops, high network losses and to accommodate future demand growth.

The rehabilitation/expansion works basically consist of construction, rehabilitation and reconfiguration of overhead and underground lines, installation of indoor and pole/pad mounted distribution transformer stations, installation of related overhead line protection equipment like load break and disconnecting switches, fuse cut-outs and low voltage distribution switchboards, supply of mandatory spares and partial dismantling of the existing distribution systems.

The key components of the network development plan for this project in Dast-i-Barchi distribution networks in Kabul City are to rehabilitate and expand new MV/LV distribution networks using ACSR/ABC and MV/LV underground cables and other necessary related equipment including the work related to distribution transformers and associated MV works in the project area of the city under system expansions.

4. SUMMARY OF WORKS

The work to be performed by the Contractor shall comprise:

(a) Supply, factory testing, packing, transport, insurance, unloading and storage in its warehouse of plant, delivery to site of plant, equipment and materials defined in schedule of prices of Section VI.

(b) Installation works for the rehabilitation/extension of underground and overhead lines, substations, construction works, erection, installation, site testing, commissioning and warranty of the plant and installations, including partial dismantling of existing installations, which comprise the present project.

Works are quantified in schedules of prices No. 4.

The Contractor shall provide complete supply and specified works at his expense, even if some materials and services to be performed are not specifically mentioned in the following description of works.

4.1 Scope of Works

The works related to erection, installation, dismantling including civil works is described in Chapter V, divided into works associated with distribution overhead lines and underground installations, taking into consideration the Distribution Standards of Chapter U, as well as works associated with indoor substations.

Included in the scope of works will also be the acquisition and management of the Contractor's warehouse as well as a training program defined in Chapters W and X of this section respectively.

The scope of supply, i.e., the quantities of plant, equipment and materials to be offered in compliance with the technical specifications is included in Chapters C to T and the technical data sheets of Chapter Y, Tables C to S including the schedule of prices of section VI.

An overview of the scope of works/supply is given below which shall include but not be limited to the scope mentioned herein.

The scope described below summarizes plant and equipment required, however the Bidder shall be aware that only the quantities of plant, equipment and materials defined in the schedule of prices of section VI will prevail.

4.2 Indoor Substations

The scope of work for this item includes rehabilitation and replacement of transformers and associated protection in some cases, rehabilitation of existing or construction of completely new indoor sub stations with 400kVA and 630kVA transformers with all associated protection and distribution equipment, this will also include all necessary civil works.

4.3 Outdoor Pole / Platform Mounted Substations

The outdoor transformer specifications are provided in Chapter G. The installation diagram for H-pole (double pole) mounting is provided in drawing No. U-TR-01.

The work consists of supply, installation and commissioning of outdoor transformer stations with 100kVA, 160kVA, 250kVA transformers along with all necessary protection and distribution equipment.

The pole mounting to be carried out on H poles as per drawing No. U-TR-01.

CHAPTER B

General Technical Specifications

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CHAPTER B: GENERAL TECHNICAL SPECIFICATIONS

1. TECHNICAL DATA

1.1 DEFINITIONS

Plant, Equipment and Materials

For all items of plant, equipment and materials, to be offered in the Bid, the Employer prefers and requires, factory production items affecting the relevant standards only. If a clause in the Bid Documents nominates a non-standard requirement, Bidders are requested to state this fact in the Bid, with the price, while offering as an alternative, the closest, suitable factory standard product, with the alternative price, for the consideration of the Employer.

Whenever the following terms or words are found in this specification they shall have the following meaning:

Medium Voltage Equipment (MV):

Equipment provided for a maximum operating voltage higher than 1000V and up to 36 kV

Low Voltage Equipment (LV):

Equipment provided for operation at 1000 V or below. (For transformers the term Low Voltage Winding is used for the side with lowest rated voltage regardless of value, ref. IEC 60076).

Reference to degree of protection (IP) is according to the classification in IEC 60529.

1.2 ELECTRICAL DESIGN DATA

All requirements and materials specified herein shall be designed manufactured and installed to conform to the following basic technical data. These are based on recognized international standards, especially IEC standards.

Electrical Design Standards for Kabul Power System

Parameter	220 kV system	110 kV system	20 kV system	0.4 kV system
Nominal voltage Un	220 kV	110 kV	20 kV	400 V (230V phase-n)
Highest system voltage Umax	245 kV	123 kV	24 kV	440 V
Design voltage Um	245 kV	123 kV	24 kV	1 kV (0.6 kV phase-n)
Voltage variation	-	-	-	+/- 7.5 %
Standard frequency	50 Hz			
Rated short time current (3s)	40 kA	31.5 kA	20 kA	12.5 kA

Electrical Design Standards for Kabul Power System

Parameter	220 kV system	110 kV system	20 kV system		0.4 kV system
System configuration	3 phases, 3 wires				3 phases, 4 wires ; 1 phase, 2 or 3 wires
Earthing	Solidly earthed	Solidly earthed	Earthed through auxiliary transformer Zy 15(20) / 0.4kV		Solidly earthed
Insulation coordination	IEC 60071-1				-
Rated impulse withstand (peak)	1,050 kV	650 kV	125 kV		-
Rated 1mn power frequency withstand (peak)	460 kV	275 kV	50 kV		2.5 kV
Minimum phase-to-earth air clearance	2,100 mm	1,300 mm	270 mm		-
Creepage distance outdoor	25 mm/kV	25 mm/kV	25 mm/kV		-
Transformers	220/110 kV	110/20 kV	15(20)/0.4 kV Distribution	15(20)/0.4 kV Substation auxiliary	-
Vector group	YNyn0	YNd5	Dyn5	Zy1	-
Rated power	100M VA	40M VA	-	400 kVA	-
Impedance	15.5%	14.9%	4.3 to 5.0%*	4.0%	-
Tap changer	On load, ± 10%, 19 positions	On load, ± 16%, 19 positions	Off load, ± 5%, 5 positions	Off load, ± 5%, 5 positions	-
Climatic and Geographic conditions	Kabul				
Altitude	1,700 – 2100 metre a.m.s.l (Altitude correction factor = 1.20)				
Dry period	June to November				
Rainy period	December to May				
Annual rainfall	327 mm				
Air temperatures	Warmest month: +25 °C Average; +35 °C noon; +18 °C night		Coldest month: -3 °C Average; +2 °C noon; -20°C night		
Air humidity	Average summer: 35%		Average winter: 75%		
Soil thermal resistivity	Average: +1.2 °C m/W		Maximum: +3.0 °C m/W		
Maximum solar radiation	1,200 W/m²				
Wind	Maximum wind velocity: 25 m/s		Wind and dust conditions: Sand and dust storms in summer		
Keraunic level	23				

Applicable standards: IEC 60038, IEC 60071, IEC 62271-200 (replaced IEC 60298), IEC 60815

1.3 Actual System Parameters

Currently the MV system in Kabul is operated at 15 kV. The project involves the provision for future conversion of the MV system to 20 kV. Parameters for the MV system at 20KV are thus provided, while only required data is provided for the existing 15 kV system.

1.4 Assumed Working Conditions for Overhead Line Installations

Maximum air temperature	°C	40
Minimum conductor temperature	°C	-10
Every day temperature	°C	25
Maximum temperature of conductor	°C	70
Maximum wind speed for design	km/h	90

1.5 Assumed Working Conditions for Underground Installations

Minimum temperature for underground installation	°C	-5
Maximum conductor temperature	°C	90
Maximum short-circuit temperature		
for conductor	°C	250
for screen	°C	250

1.6 Climatic Conditions

All equipment shall be entirely suitable for use under the prevailing site conditions.

The applicable climatic conditions are given in the table under sub-clause 1.2 to this chapter.

Those characteristics have to be taken into consideration during all phases of the works, design calculations, manufacture, transport and erection.

1.7 Minimum Safety Factors (SF)

	SF
o All types of poles under normal working loads	2.5
o All types of poles under asymmetric load (broken wire condition)	1.1
o Foundations for all types of poles under normal working load	1.5
o Foundations for all types of poles under asymmetric loads (broken wire)	1.1
o Phase and earth conductors based on ultimate strength at min. temperature and max. wind	2.5
o Phase and earth conductors at every day temperature, still air, final tension	5.0
o Insulator strings complete with fittings under maximum tension (elastic limit)	2.5
o Insulator strings complete with fittings based on minimum failing load	3.0
o Mid-span joints and dead-end clamps based on conductor or earth wire ultimate strength	1.0

1.8 Minimum Clearances

		MV	LV
o Ground accessible to pedestrians only	m	6.5	5.0
o Open country	m	6.0	5.0
o Roads, streets	m	7.0	5.5
o Buildings, accessible points, flat roofs or those upon which a man may stand (vertical – above and below)	m	4.5	2.7
o Clearances from structures upon which a man may stand other than vertical (bare or covered)	m	2.1	1.5
o Clearances from structures upon which a man may stand other than vertical (Fully Insulated)	m	0.6[1]	0.1[2]
o Telecommunication lines	m	2.5	0.3
o Trees	m	2.5	0.3
o Any steel structure	m	3.0	0.3

[1] For fully insulated MV cable without earthed screen

[2] LV ABC shall be off standing: may be attached to buildings on approval of DABM.

2. REQUIREMENTS

2.1 DRAWINGS AND CALCULATIONS

The drawings in the Bidding Documents supplied by the Employer shall be used for designing the works, but shall not be used for construction purposes or for supplying plant and materials unless authorized by the Project Manager. The drawings in the Bidding Documents, Chapters U and Z, of this Section do not show the limits of the scope of supply and works.

In addition to what is stated in the Conditions of Contract, the following shall apply:

The sizes of all documents and drawings shall conform to the ISO standard i.e.:

- A1 594 mm x 841 mm A2 420 mm x 594 mm
- A3 297 mm x 420 mm A4 210 mm x 297 mm

Sizes larger than A1 shall be avoided. All documents in size A3 and A4 shall be bound in hard covers.

The schematic diagrams, apparatus and cable lists shall have a size of A4 except for the transparency copies of schematic diagrams that shall be in A3. Scales to be used on the drawings shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

All drawings specially made for this project including civil work drawings, mechanical drawings, layout drawings and circuit diagrams shall be compiled on a computer aided drawing system and as part of the as built documentation be handed over on a CD with a format readable in Auto-cad latest version, or another format to be agreed upon.

The Contractor shall during the total project time maintain a List of Documentation to be updated by him whenever needed. The List of Documentation shall include the date of original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for the submittal of the documentation.

The Contractor shall submit to the Project Manager according to Section VII, Appendix 7 for approval in connection with and before proceeding with his fabrication, erection, installation or construction of the works designs, engineering calculations, drawings, samples, detailed specifications, supports and methods of erection, installation or construction, provided that the Contractor shall be not under any obligation to supply copies of shop drawings except for civil works.

The Contractor's Drawings shall show all dimensions and tolerances and other related information necessary to meet all requirements for satisfactory fabrication, erection, installation and construction.

The International System of Units (SI Units–ISO/R 1000) shall be used throughout the Contract. Deviations require the approval of the Project Manager.

Fabrication erection, installation and construction of any portion of the Works prior to the approval of the Contractor's Drawings and calculations shall be at the Contractor's Risk.

The Contractor shall check all drawings and calculations carefully for correctness and compliance with the specifications and requirements of the Contract.

The Contractor shall submit only those drawings for approval which have been certified for construction by the Project Manager.

In case the Contractor submits preliminary drawings or information only, he shall stamp these "Preliminary" or "For Review".

The Contractor shall furnish all final arrangement drawings, calculations, shop and working drawings of main plant and equipment according to articles 18 and 20 of the GCC of Section IV.

"Approved" means the Contractor can proceed with fabrication/erection/installation.

"Approved Except as Noted" means the Contractor can proceed with fabrication in accordance with comments; the document shall be re-submitted to the Employer for final approval within fourteen (14) days of receipt by the Contractor.

"Not approved" means the Contractor shall not proceed with fabrication; the document shall be revised in accordance with the comments and shall be re-submitted for approval.

"For Review only" means that no approval is required and the document shall be considered for information only. The Project Manager may raise objections or make comments which shall be taken into consideration by the Contractor.

The Contractor's documents shall be clearly marked "For Approval" or "For Review only".

The Project Manager may change the Contractor's request "For Approval" into "For Review only' and vice versa.

2.2 CODES, STANDARDS, SPECIFICATIONS

All works shall be selected, designed, manufactured, tested and maintained in conformity with the current issues of the relevant, internationally recognized codes, standards and specifications, such as IEC, ANSI, ASTM, DIN-VDE, BS and/or other International Codes as approved by the Project Manager, valid at the date 28 days prior to bid submission in accordance with Article 20.2 of Section IV, GCC. Any specific requirements as stated in the Technical Specifications shall be binding, however, plant, equipment or materials meeting other standards which ensure an equal or higher quality than the specified standards will also be accepted.

The Project Manager reserves the right to reject any or all of the alternative codes or standards proposed by the Contractor.

The precise standard, complete with identification number, to which the various plant, equipment and materials are manufactured shall be specifically stated in the technical data sheets The Contractor shall have access to relevant standards if verification of compliance is required.

The Contractor shall deliver at his own cost one (1) complete set of original electronic version of the selected plant, equipment specifications and drawings to the Project Manager twenty eight (28) days before the placement of orders for plant and equipment for the Works.

One (1) set shall be kept at the Contractor's site office and shall be accessible to the Project Manager or his representative during working hours.

2.3 MATERIALS AND WORKMANSHIP

2.3.1 Quality of Materials

All materials supplied under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working conditions without distortion or deterioration in the setting up of undue stresses in any parts and also without affecting the suitability of the various parts of the Works for which they were designed. No toxic material (such as Halon, PCB, and Asbestos) shall be used.

2.3.2 Standardization of Plant, Equipment

The Contractor shall be responsible for the standardization of all mechanical and electrical plant, equipment, materials and devices.

Where electrical sockets are specified, Afghanistan standard sockets shall be used. Single phase sockets shall be 16A with earth plug, if not specified.

If not specified, LV power fuses 63 amps and above shall be of high rupturing capacity cartridge, type NH gl, according to IEC 60269 or DIN VDE 0636. All fuse bases shall have a load switching capacity and a thermal rating equal to the rating of the largest fuse it can accommodate.

Miniature circuit breakers shall replace fuses in control and power circuits below 63 amps.

2.3.3 Surface Treatment and Painting, Electrical Plant, Equipment

2.3.3.1 Cleaning and Painting

Before painting or filling with oil or compound all un-galvanized parts shall be thoroughly cleaned, free from rust, scale, burrs, grease and moisture and all external rough surfaces on castings shall be filled.

Successive coats of paint shall be applied to a clean, dry and properly prepared surface. Each coat shall be compatible with the preceding coat and the coat to follow.

The color and shade of all painted external surfaces shall be subject to approval by the Project Manager.

The following minimum painting requirements shall apply to all ferrous parts unless the Supplier can show, to the satisfaction of the Project Manager that any alternative he proposes is in all respects equal or superior to the specified requirements:

Apparatus	Painting
INTERNAL SURFACES	
Oil filled chambers and tanks	One coat of oil resisting varnish or paint
Kiosks and apparatus boxes for use outdoors	Three coats of paint, the final coat being an anti-corrosion finish colored white or light grey
Cubicles, kiosks and apparatus boxes for use indoors	Three coats of paint, the final coat being a white or light color.

EXTERNAL SURFACES	
All un-galvanized surfaces other than nuts, bolts and washers may be removed for maintenance purposes, for use outdoors	At Works (a) One priming coat of corrosion inhibiting paint applied immediately after cleaning (b) Two coats of non-glossy oil and weather resisting paint applied after inspection and testing and before dispatch. At Site One finishing coat of glossy, oil and weather resisting, non-fading paint applied after erection is complete. For equipment dispatched completely assembled, the final coat may be applied at the works unless otherwise required by the Project Manager.
Exposed, un-galvanized nuts, bolts and washers which may be removed for maintenance purposes for use outdoors	
Panels, Cubicles, Kiosks and apparatus boxes for use indoors	Three coats of paint. The color and finish of the final coat shall be subject of the Project Manager's approval.

2.3.3.2 Galvanizing

Galvanizing shall be applied by the hot dipped process. The preparation for galvanizing and the galvanizing process shall not affect the mechanical properties of the material being coated. Drilling, punching, cutting and bending, shall be completed before galvanizing.

The zinc coating shall be smooth, clean and 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. All galvanized steel that has been cut, drilled or worked on site shall be painted with an approved zinc rich paint.

The average thickness of the zinc coating shall be equivalent to not less than 610 g/m^2 of zinc for all surfaces except steel wires, bolts and nuts. Galvanizing will be tested in accordance with the appropriate standards in order to determine that it complies with this requirement. The thickness of the zinc coating for steel wires shall be in accordance with international standards and shall be approved by the Project Manager. All galvanized wires on which tools have been used or cut shall be treated with approved bitumastic paint.

All bolts and threaded rods for the connection of galvanized steel parts shall be galvanized including the threaded portion(s) to a minimum average coating weight of 305 g/m^2. The threads of all bolts and threaded rods shall be cleared of burrs, spelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Project Manager. All nuts shall be galvanized with the exception of the threads that shall be oiled.

White rust formation subsequent to galvanizing must be inhibited using an approved inhibitor applied according to the manufacturer's instructions. Material on which galvanizing has been damaged shall be re-dipped unless, in the opinion of the Project Manager the damage is local and can be repaired by applying a coat of galvanizing repair paint. Where such repair is authorized, the damaged area shall be cleaned by wiping with clean rags saturated with mineral spirits or xylem followed by wire brushing. After wire brushing, the area shall be re-cleaned with solvent to remove residue and shall be given a minimum of two coats of zinc rich paint in accordance with the manufacturer's instructions. Such painting shall be applied as soon as possible and in no case more than 4 hour after the surface preparation.

2.3.6 Insulating Oil and Gas

All electrical equipment requiring insulation oil or other insulation or gas shall be furnished with the first filling including flushing, if required. Insulating oil shall comply with IEC 60296.

The insulating oil shall not contain matters that are not biodegradable such as PCB etc. Certificates shall be provided that verify PCBs are not present in any oil used.

The Contractor shall endeavor to employ, as far as practicable, one type and make of insulating oil only, for all the electrical plant and equipment.

SF_6 gas shall comply with the requirements of IEC 60376. The high pressure cylinders for shipment and storage of the SF_6 gas shall comply with the applicable national regulations.

All the necessary pipes, couplings, flexible tubes and valves for coupling to the switchgear for filling or evacuating all the gases or oil to be used, with all necessary instructions for the storage of this equipment, shall be provided.

2.3.7 Aluminium and Aluminium Alloys

Aluminium shall be of high commercial quality. The composition, including the percentage and nature of any impurities, shall be stated in the Schedules. All aluminium alloys shall be of approved compositions as stated in the Schedules. Aluminium and alloy castings shall be sound and free from air pockets and pinholes.

2.3.8 Bolts, Studs, Nuts, Screws, Washers, etc

All bolts, studs, nuts, etc., shall have a standard metric threading and conform to the relevant standards as regards shape and tolerance. Bolt threads shall be cold rolled. They shall be marked with the manufacturer's symbol and strength class.

Bolts and nuts for electrical connections shall be preferably of brass not less than M6 size. Alternatively size M5 may be used, but these must be of stainless steel, phosphor bronze or high tensile brass.

All bolts, studs, nuts, washers, screws, equal to or above 10mm diameter, if not in stainless steel or other corrosion-resistant material, shall be hot-dip galvanized, except for bolts above Strength Class 8.8. In this case, corrosion-resistant material will be required.

Bolts, etc, smaller than 10mm diameter shall be electrolytic zinc-coated, if not provided in stainless steel or other corrosion-resistant material.

Bolts, nuts, studs and screws, which require frequent tightening and unbolting during inspection or maintenance procedures shall be of stainless steel.

All bolts and nuts shall be hexagonal, either normally or of the round head socket type and secured in an approved manner against becoming loose during operation.

The Contractor shall supply the net quantities plus 5% of all bolts, nuts, washers, screws and other similar items and materials required for installation of the works at the site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the equipment has been completed shall become spare parts and shall be packed, marked and given to the Employer.

Bolts shall not protrude more than four threads or 10 mm beyond the nut (except for terminals) and not less than two full threads.

2.3.9 Nameplates and signs

All equipment shall be clearly and permanently labeled in English and approved by the Project Manager. Where labels are provided for making clear the method of operation of plant and equipment they shall be concise and preferably diagrammatic in form.

All outdoor nameplates and signs shall be made of non-corrosive weatherproof material as trifoliate, aluminum or stainless steel.

Danger labels shall have red lettering on a white background. All other labels shall have black lettering on a white background.

Before production of labels and notices the Contractor shall submit to the Project Manager full scale drawings of the proposed labels

2.3.10 Locking Devices and Padlocks

Facilities for applying safety or security padlocks to circuit breaker operating mechanisms, isolator and switch operating handles, control cubicles, outdoor cabinets etc., shall be provided. Where padlocking is specified, two padlocks, each with two keys are to be provided for each hasp.

2.3.11 Pole Riser

All wires, cables and U-guards running up or down poles to meters, transformer, switches, etc. shall be firmly and neatly secured in place with metal stainless steel bands or reinforced plastic, machine tightened and sealed tape.

2.4. DESIGN AND CONSTRUCTION

2.4.1 General Requirements

All plant and equipment shall be designed to ensure reliable and safe operation under the atmospheric conditions prevailing at site and under sudden variations of load voltages and short circuits on the system.

In no part of the plant or equipment, including busbars, connections, isolators, fuses, contacts and cable boxes shall the temperature rise exceed the values specified in the relevant IEC or equivalent Standards.

Corresponding parts liable to renewal shall be interchangeable. When required by the Project Manager, the Supplier shall demonstrate the compliance with this requirement. All apparatus shall operate without undue vibration and with the least practicable amount of noise.

Means shall be provided for the easy lubrication of all bearings and where necessary, of any mechanism or moving part. Grease lubricators shall be fitted with hexagon nipples. All mechanisms shall, when necessary, be constructed of stainless steel, brass or gunmetal to prevent sticking due to rust or corrosion.

All taper pins used in any mechanism shall be of the split type. All connections and contacts shall be of ample section and surface for carrying continuously the specified full load currents without undue heating and shall be secured by bolts or set screws of ample size fitted with locking devices of approved type and material.

All rubbing or wearing surfaces shall be machine surfaced. Joints employing a gasket material shall be so constructed that the packing is maintained under sufficient compression in all parts so that an efficient joint can be made without the use of jointing compounds. Gasket material shall be of the minimum thickness necessary and have approved composition.

All apparatus shall be designed to exclude vermin and insects from entering the plant, equipment.

All outdoor plant, equipment including bushing insulators and fittings shall be designed so that water drains from the surfaces.

2.4.2 Erection Marks

All plant and equipment that requires assembly at site shall have distinguishing marks on it to facilitate erection and to identify the material in relation to drawings, material lists or shipping documents. All marks shall be legible and easily visible. Where relevant, erection marks shall be stamped before galvanizing and shall be clearly visible after galvanizing.

2.5 TOOLS

The following three types of tools are distinguished:

1. Standard tools,
2. Tools for erection and installation,
3. Special tools.

2.5.1 Standard and Special Tools

A complete set of standard and special tools shall be supplied for each type of installation to assemble and fix the plant and equipment supplied under this Contract, together with all special tools required for the operation, adjustment and maintenance of the plant, equipment.

2.5.2 Tools for Erection and Installation

These tools will be brought to site in order to erect and install the complete supplied plant and equipment.

These tools shall remain the property of the Contractor and will, therefore, after commissioning be re-exported from Afghanistan in case of foreign Contractor.

Alternatively they could remain partly or completely in the Employer's country for payment of an amount mutually agreed upon between the Employer and the Contractor.

2.6 Spare Parts

The required categories and minimum quantity of spare parts are indicated in the Price Schedules in Section VI.

Beside the specified spare parts, the Contractor shall list in detail the recommended spare parts he considers necessary for safe and reliable operation and maintenance, together with their individual prices, in the respective schedule of Recommended Spare Parts.

The Employer reserves the option to order all or part thereof or supplementary spare parts. These prices shall be kept firm for the period until the expiration of the Defects Liability Period of the Contract.

The Contractor shall ensure that sufficient spare parts and consumable items are available for his own use during commissioning of plant. Spares ordered by the Employer shall not be used by the Contractor without the written consent of the Employer.

Any spare plant, equipment, parts and tools shall be subject to the same specification, tests and conditions as similar materials supplied under the Contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the plant and must be suitably marked and numbered for identification and prepared for storage by greasing or painting to prevent deterioration.

All spares shall be accompanied by four (4) copies of storage instructions in English and local language, Dari, together with relevant catalogues.

The spare parts are to be delivered to the warehouse of the Contractor with catalogues labels, brands and other signs for their identification, with everything to the complete satisfaction of the Employer and these shall be delivered to the Employer's Stores prior to Taking Over.

2.7 Packing, Shipping, Transport and Lifting Devices

2.7.1 Packing

The Contractor shall prepare and pack all plant, materials and equipment for shipment in such a manner that they are protected from damage during shipment and shall be responsible for and make good any and all damage resulting from improper packing, whether this is done at his own works or those of any supplier.

Packing shall give adequate protection to the enclosed materials against mechanical damage during transport to its final destination, including rough handling during sea, rail and road transport and transition from one mode of transport to another.

Packing should be stout, close-boarded wooden cases of adequate thickness, suitably braced and banded and lined internally with water-resistant material or equally solid enclosures.

Steelworks sections and similar items may be bundled, provided that the ends are adequately protected and the bands or wires are robust, which secure each bundle.

Indoor electrical plant, equipment must be enclosed in welded polythene envelopes inside packing cases and the envelopes shall be evacuated or have a desiccant inside.

All items in cases or crates shall be secured so that they are not free to move and cannot work loose in transport. If rotating parts are shipped within their bearings or mountings, they must be adequately braced and restrained to prevent relative movement. Loose items shall be placed in bags in a case, each bag having stitched onto it a label indicating the number and nature of its contents. Where a filler material is used to restrict movement or provide additional protection, it must be inorganic and non-hygroscopic.

All surfaces liable to corrosion shall be thoroughly cleaned and special steps adapted to the nature of the materials and the time interval between packing and unpacking shall be taken to prevent corrosion. These steps may constitute the greasing on surfaces, the application of protective coats, enclosure of the items in a hermetically sealed container, the addition of vapor phase inhibitor paper to the package or other approved means.

Steps shall be taken to ensure that moisture, moulds, insects or rodents cannot damage insulated materials. Items that include materials liable to be damaged by moisture shall be packed in hermetically sealed containers in which silica gel, or some other approved desiccant has been inserted.

Cases shall be marked with large lettering to show which side of the case is to be up, and if the contents are fragile, marked "FRAGILE" in large letters with the international wineglass symbol. Packages shall be marked with their place of destination in such a way that rough handling or the effect of weather cannot remove or obliterate the marking. Each item shall be marked with its gross weight and, for all lifts over two tons, marks on the cases shall show the correct positions for the slings.

Special steps shall be taken to guard against theft during transport. No small items such as padlocks, nameplates and so forth that could be torn off or unscrewed shall be accessible.

Cases, crates, barrels and drums shall be banded in such a manner as to obstruct the theft of any of the timber used for packaging and the bands shall be so secured that they are not rendered ineffective by shrinkage of the wood.

A descriptive and fully itemized list shall be prepared of the contents of each packing case. A copy of this list shall be placed in a waterproof envelope under a metal or other suitable plate securely fastened to the outside of one end of the case and its position indicated by stenciling on the case. Where appropriate, drawings showing the erection markings of the items concerned shall be placed inside the case.

All stenciled markings on cases and crates, or other markings on descriptive metal tabs fixed to cable drums, bundles of structural steelworks and so forth, shall be applied in two places with a material which cannot wash off and shall be additional to any erection or other marks or impressions which may be specified elsewhere.

Shipping marks are to be stenciled in oil based paint in block letters and symbols. When unobstructed flat, smooth surfaces of sufficient size are not available on the case for the shipping marks they are to be stenciled on marine-ply notice boards of adequate size and of at least 6 mm thickness securely fastened to the packing case.

All packing cases, excluding steel containers, shall remain the property of the Employer.

2.7.2 Transport

The Contractor shall be deemed responsible for the following:

To load and transport the plant, equipment and materials from the place of manufacture, whether this is from own works or from any supplier, to the delivery place in Afghanistan.

To off-load, clear and transport to site all plant, equipment, materials including temporary storage.

To obtain permission from relevant authorities to use airport or Site unloading, highway and bridge facilities required for transport of his plant and equipment.

To insure to the full value of the plant, equipment and material for freight, for securing and forwarding of all shipping documents and for the payment of all shipping and unloading documents and charges.

To obtain and verify all information specified regarding transport limitations.

To obtain and verify all information specified regarding adequate handling equipment for unloading the heaviest pieces of plant and equipment.

To bear all costs of repair or replacement of the plant, equipment arising from damage during transport and unloading or re-loading.

To select proper routes to meet his needs and shall bear all extra costs resulting from the selection of such routes.

The Contractor shall inform the Employer of the anticipated shipping dates by a 30 days written notice containing identifications, symbols, descriptions, weights and sizes of plant, equipment, materials in the shipment.

2.7.3 Lifting Devices

The Contractor shall provide bolts with shackles to facilitate the handling and lifting of supplied plant, equipment and materials.

The Contractor shall make his own arrangements and enquiries with regards to the loading, unloading and transport of all Construction plant, equipment and materials required for the works.

2.8 TESTS AND INSPECTIONS

2.8.1 Basic Principles

All plant, materials and equipment used in the Contract Works are subject to inspection by the Project Manager.

The inspections and tests shall comply with the requirements specified in the relevant Clause 23 of the General Conditions of Contract, Section IV.

The Contractor shall conduct the tests in accordance with the provisions of Technical Specifications and that of the applicable standards.

Where the methods of tests are not specified in the standards or if there are options in the relevant standards, the Contractor shall submit to the Project Manager for approval the methods by which he proposes to conduct the tests.

Procedures for those tests which are beyond the service conditions specified in the relevant standard(s) shall be approved the Project Manager.

All plant, equipment and materials necessary for the tests shall be furnished by the Contractor. Measuring apparatus and their calibration certificates shall be approved by the Project Manager.

Any delay in delivery due to a re-test shall not constitute a release of the Contractor from his responsibilities for delay of the considered work, and such a delay shall not be a reasonable ground for time extension of the contract.

2.8.2 Factory Tests

The factory tests shall be divided into type tests, sample tests, routine tests and special tests.

The tests generally described in the Technical Specifications as type tests, shall be carried out on one item of plant, equipment of each type and rating. If evidence is available of successful type tests on identical plant, equipment or on plant, equipment which is for practical test purposes identical as determined by the Project Manager, in an internationally recognized independent testing laboratory, this may be accepted by the Employer in lieu of these tests, if not otherwise specified in the Technical Specifications.

Only plant, equipment which has been type tested in the last five years may be acceptable to the Employer. These type tests should have been conducted on the equipment/material produced from the plant, from where supplies are intended.

Valid certification of such type testing must be provided to the Project Manager before any item is shipped or dispatched from the works. Test certificates for all plant, equipment and materials will be required by the Project Manager, before the Project Manager provides the certifying bank with authority to release funds from the letter of credit, upon shipment. The letter of credit will be established, so that such authority will be required, along with the usual prescribed shipping documents.

The tests generally described in the Specifications as routine tests, shall be made on each piece of plant, equipment to be supplied.

The factory assembled units shall be completely assembled, adjusted and tested at the factory. After assembly the complete units shall, as far as possible, be tested for operation under design conditions to assure the proper functioning of the plant, equipment.

2.8.3 Site Tests

Upon completion of erection of the various parts of the Works, the Contractor shall perform preliminary and functional tests in order to check the operation of the plant and its conformity with the Specifications.

The tests on completion shall demonstrate:

- The completeness of the Works
- The correctness of the assembly and installation
- The safety and reliability of the Works under all operating conditions.

The basis on which the test program shall be compiled is:

- The parameters quoted in the data sheets
- The requirements stated in the Bidding Documents
- The requirements of the approved Standards and Codes of Practice

All plant shall be inspected and tested for correct positioning, adjustment, clearance with all such items, which may affect their performance and reliable operation. Tests and inspections for correct connections, installations, insulation and grounding shall also form part of the inspection.

2.9 SUPPLIER'S QUALITY ASSURANCE PROCEDURES

The following procedures apply to major plant, equipment and materials such as distribution transformers, switchgear, MV and LV equipment.

The Contractor and his manufacturers shall have established a quality assurance systems based on ISO 9001 or 9002. The Contractor shall include documentation of the system with a list of current procedures, an organization chart of the quality organization and the name of the quality manager. The Contractor shall also submit a list of quality revisions performed in the last twelve months with a list of closed and unclosed findings as well planned revisions in the coming twelve months.

The Contractor shall submit for approval a program of quality control and inspection procedures to ensure that the plant, equipment during manufacture and on completion complies with the specified requirements.

CHAPTER C

Part I - Medium Voltage Underground Cables and Accessories

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PART I – MEDIUM VOLTAGE UNDERGROUND CABLES AND ACCESSORIES

I.1. GENERAL DESCRIPTION OF CABLES AND OPERATION

The 12/20 kV cables to be used in the medium voltage system shall be of single core type with stranded copper conductors, with extruded firmly bonded semi-conductive layers under and over the XLPE insulation, with copper wire screen.

A reliable corrosion protection shall be provided by a black coloured outer PE sheath.

The cables shall be suitable for outdoor and indoor use and direct laying in ground and water, considering the prevailing climatic site conditions specified in chapter B of this section. The cables shall be suitable for operation in an effectively earthed as well as resistance or reactance earthed system.

The cable conductors cable shall be annealed copper; the electrical and physical characteristics of the metal to be as specified in IEC 60228.

The characteristics of the insulation and sheath shall be as specified in IEC 60502 and this Specification. The insulation thickness shall be sufficient to meet the electrical, as well as the mechanical requirements.

The cable ends shall be effectively sealed to prevent penetration of moisture.

I.2. STANDARDS

The cables shall be manufactured to conform to this Specification and the following Standards or other equivalent Standards. In all cases, the Contractor shall provide one copy of the applicable Standards.

IEC 60502-2: Power cables with extruded insulation and their accessories for rated voltages from 6 kV (Um = 7.2 kV) up to 30 kV (Um = 36 kV).

IEC 60502-4: Test requirements for accessories for cables with rated voltages from 6 kV up to 30 kV.

IEC 60540: Test methods for insulation and sheaths of electric cables (elastomeric and thermo plastic compounds).

IEC 60228: Conductors of insulated cables.

I.3. DESIGN DATA FOR CABLES

The technical data for each type of cable are to be found in the technical data sheets of Chapter Y, Tables C of this section.

The single core cable with XLPE insulation, longitudinally water proof screens and PE sheath shall be Type N2XS(F)2Y according to IEC Standards.

Conductors: Single core circular stranded, annealed, high copper, according IEC 60228, clause 2.

Cable Section: As specified in the technical data sheets of Chapter Y and Price Schedules of Section VII. Where the quantities are marked with zero, only unit prices are to be inserted.

Triple extruded insulation: Cross-linked polyethylene according to IEC 60502, clause 5, with conductive and semi-conductive layers.

~~Outer sheath: Outer protective covering shall be of termite resistant black PE.~~

Rated voltage: 12/20 kV (Um = 24 kV)

I.4. INSPECTION AND TESTS

Cables to be supplied shall be tested at the Manufacturer's works before shipment. During the manufacturing process of any items, the Employer/Project Manager may inspect the process. The Contractor shall give adequate notice of manufacturing programs and place of manufacture to schedule any factory inspection.

The following tests are required for the cables and accessories to the nominated IEC Standards:

- Type Tests
- Routine Tests

I.4.1 TYPE TEST

The Employer may accept certified test certificates on standard products from a recognized testing laboratory.

I.4.2 ROUTINE AND SPECIAL TESTS

As per the Standards.

I.5. QUALITY ASSURANCE

The bidder shall submit to the Employer with the bid the ISO 9002 certificate or equivalent. Failing to do so may lead to the rejection of the offer.

I.6. ACCESSORIES FOR 12/20 kV CABLES

I.6.1 GENERAL

The joints, terminations, connectors and jointing accessories for the underground power cables shall conform as follows.

Joints and terminations shall be supplied in complete kit form with all materials and components required to complete the installations. Connectors and terminals shall also be included in each kit.

Heat shrink, pre-moulded joints or terminations, or a suitable alternative shall be offered for XLPE cables.

All components shall be capable of being stored without damage or deterioration at temperatures up to 40℃. The material expiry date s hall be marked on all packages, where appropriate.

Details of all equipment, tools and protective clothing required to complete the joint or termination shall be included with each joint or termination.

I.6.2 JOINT AND TERMINATION MATERIALS

Components shall not be adversely affected in any manner by contact with other materials normally used in the construction of cable joints or terminations and shall not increase the rate of corrosion of any metals with which they may come into contact.

Components supplied with adhesive coatings shall have means to prevent the coated surfaces from adhering to each other.

Joints and terminations for armoured or shielded cables shall include all items needed for wire or tape clamping.

The cover thickness of insulation over the connector shall be uniform and equal to or greater than the cable insulation thickness as given in IEC 60502.

If applicable, the protection provided by galvanised steel wire armouring shall be reinstated over the joint.

Electric field stress control shall be provided in the joint or termination.

Joints shall provide waterproofing, mechanical and electrical protection and they shall be completely sealed from cable jacket to cable jacket. Joints shall accommodate crossing of the cores.

Terminations shall be designed to provide a complete moisture seal, including the crotch area of multi-core cables and complete re-jacketing of the individual cores. They shall be generally suitable for indoor and outdoor installation and they shall be resistant to ultra-violet radiation and chemical attack.

The minimum creepage distance for 24 kV outdoor terminations shall be 600 mm.

The adhesives used shall have a softening temperature of not less than 90°C; they shall be compatible with other components and after curing, they shall not flow at normal service temperatures.

I.6.3 CONNECTOR AND TERMINAL MATERIALS

Connectors and terminals shall perform without undue stress under normal, cyclic loading and fault conditions and shall not limit the rating of the cables which they joint.

The Employer uses normal hand operated compression tools. Connectors offered shall be suitable for compression by a range of tools and interchangeable dies. The number of different dies necessary to make a connection should be a minimum.

The Contractor will indicate the range of tools and dies for which these connectors are suitable.

The ends of connectors and terminals shall be suitably chamfered or coned to facilitate insertion of the conductors. Connectors shall have a solid central barrier to facilitate the insertion of the conductor to the correct depth.

Compounds or greases for improving the contact between the connector or terminal and the conductor are permitted. They must be chemically neutral to the connector, terminal and conductor materials and must be injected at the factory into the connectors and terminals for delivery.

Cable connectors and terminals shall be able to accommodate typical variations in dimensions of cables supplied by different manufacturers.

I.6.4 MV TERMINATION KITS

a) 12/20 kV outdoor termination kits shall be supplied for terminating 35mm² to 240 mm² cables on the distribution lines.

   This kit should include a galvanised steel mounting arrangement that will enable the termination to be attached to concrete distribution poles.

b) 12/20 kV indoor termination kits shall be supplied for terminating 35mm^2 to 240 mm^2 cables. All 12/20 kV terminations supplied for termination of cables to switchgear units and transformers shall be of the fully shrouded type so that the termination, when made, fully insulates the cable lug and the equipment terminal.

The terminal kits shall comprise all the items necessary to complete the termination including compression lugs.

I.6.5 MV Straight Joint Kits

The 12/20 kV underground straight-through joint assemblies shall be supplied for use with single core non armoured cables.

The cable route is subject to periodic flooding and sections of the cable and the cable joints may be submerged in water for long periods. The cable joints must withstand these installation conditions.

The through joint repair kits shall comprise all the items necessary to complete the functions including compression connectors.

Connector and terminal should not react chemically with the cable conductors to which they are connected.

I.7. CABLES DRUMS

The underground cables shall be delivered wound on strong wooden drums treated to an approved international standard by impregnation with copper-chrome-arsenate (CCA) preservative to resist rotting, termite and fungus attacks.

The drums shall be non-returnable. The central hole of the drums shall be reinforced with a steel plate of minimum thickness 10 mm, to fit an axle size of 95 mm diameter.

The maximum weight of any drum shall not exceed 1500 kg.

The interior of the cable drums shall be lined with bituminous paper to prevent the cables from being in contact with the timber. Waterproof paper and felt lining shall overlap the seams by at least 20 mm and the seams shall be sealed.

Drums shall be adequately protected by securely fastened substantial wooden battens around the periphery. These battens shall be secured by means of steel tape bindings.

Cables shall be fastened around the periphery of the drum. Cables shall be supplied with both ends properly capped and protected against damage. Each drum and one end of each length shall bear a metal label detailing manufacturer's name, specified voltage, cable type, conductor size and length. Cable drums shall be suitable for outside storage for a minimum period of five years in the prevailing climatic conditions without undue deterioration.

The inner cable end attached to the drum shall be capped and sealed in such a manner that the core screening and sheath can be insulation tested from the outer cable and without removing the inner end cap.

All nails and metallic parts of the inner surfaces must be countersunk so that they cannot damage the cables.

The thread of bolts used to strengthen the cable drums shall be such that the nut can be tightened but cannot be easily removed.

Drums shall not be treated with chemicals injurious to the cables.

I.8. NAMEPLATES, LABELS

All material and equipment to be supplied- cables and accessories- shall be provided with a permanently attached nameplate or label for identification. Each item of equipment shall be provided with a rating plate containing the necessary information specified in the relevant IEC Standards.

For the cable drums, labels shall state:

- Serial number of drum
- Cable details
- Conductor type and size
- Number of cores
- Length in meters
- Year of manufacture
- Gross and net weight in kilograms
- Drum measurements
- Employer's name
- Contractor's (Manufacturer's) name
- Contract number
- Country of origin

CHAPTER C

Part II - Low Voltage Underground Cables and Accessories

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PART II – LOW VOLTAGE UNDERGROUND CABLES AND ACCESSORIES

II.1. GENERAL DESCRIPTION OF LOW VOLTAGE CABLES

This Specification covers single, three and four cores copper conductors, PVC insulated PVC sheathed NYY cables (VDE Standard reference; or to equivalent IEC Standard) directly buried in the ground and covered by reinforced concrete cable protectors.

Cables are also used for connections between the low voltage switch board of MV/LV indoor/outdoor/pole mounted distribution substations and the LV overhead lines, as well as customer service connections.

The technical data of each type and size of LV underground cable are to be found in the technical data sheets of Chapter Y, Tables C of this section. Quantities of the different sizes are specified in the price schedules of Section VII. Where the nominated quantities are zero, only unit prices are required.

II.2. STANDARDS

The cables shall be manufactured to conform to the present Specification and the following Standards without excluding other equivalent Standards. In all cases, the Contractor shall provide one copy of the applicable Standards.

IEC 60228	:	Conductors of Insulated Cables
IEC 60502	:	Extruded Solid Dielectric Insulated Power Cables
DIN VDE 0271:		PVC Insulated Cables with Nominal Voltages up to 6/10 kV

II.3. ELECTRICAL CHARACTERISTICS

The cables are 0.6/1 kV rated, PVC insulated cables as defined in the technical data sheets of Chapter Y.

Cable design and performance characteristics shall conform to the nominated standards.

II.4. CABLES STRUCTURE

Cables conductors may be stranded sector shaped, stranded or solid circular conductors with PVC insulation PVC sheathed as specified in the technical data sheets of Chapter Y. The outer sheath shall be black PVC, ultra-violet stabilized.

II.5. ACCESSORIES FOR LV UNDERGROUND CABLES

II.5.1 LV Termination Kit

The LV termination kit shall be supplied for use with single, three and four core PVC insulated NYY (VDE Standard reference, or equivalent IEC Standard) copper cables as specified above including the technical data sheets of Section Y, Tables C.

The cables kits shall consist of:

- 1, 3 and 4 core glove
- heat shrinkable coloured core identifier tubes
- installation instructions
- other items necessary to complete the kit

II.5.2 LV Underground Straight Joint Kit

The LV underground straight joint kit shall be supplied for the same cables as specified above.

The cable joints may be in water for long periods. Joints shall be waterproof.

The through-joint repair kits shall comprise:

- compression connector
- sealant tape
- installation instructions
- other items necessary to complete the kit

II.5.3 Termination And Jointing Materials

Termination and jointing materials for LV power cables shall provide electrical stress control, non-tracking exterior surfaces and sealing against water and pollution.

One, three and four-core and single phase two-core cable joints and terminations shall use a heat shrinkable polymeric molded glove to provide mechanical stress relief and sealing.

Electrical stresses shall be controlled by a high resistivity, heat shrinkable polymeric tubing per manufacturer's recommendations.

Heat recoverable polymeric materials and terminations shall be in compliance with IEC 60502.

The materials and the completed terminations and joints shall be appropriate for the type of service, size and voltage and shall include ferrules and other materials necessary for the terminating and jointing of the conductor, including clamps, braid, necessary for the termination and jointing of screen and sheath for earth continuity.

II.5.4 END CAP

Heat shrinkable end caps shall be supplied for temporary use during construction for all types of cables specified in this chapter.

CHAPTER D

Service Wires and Accessories

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Chapter D : Aluminium Service Wire

1 CABLES

1.1 Scope

This Specification covers the design, manufacture and testing of the following types of 0.6/1kV PVC insulated stranded Aluminium weatherproof Service Wire, 4x(10, 16 and 25) mm^2 and 2x(6, 10, 16 and 25) mm^2, with one core bare and all of them sheathed.

1.2 Standards

IEC: International Electrotechnical Commission

- IEC 60502 — Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um=1.2kV) up to 30 kV (Um=36kV)
- IEC 60228 — Conductors of insulated cables
- IEC 61089 — Round Wire Concentric Lay Overhead Electrical Stranded Conductors
- IEC 60207 — Aluminum stranded conductors
- DIN 48205-5 — Aluminium Stranded Conductors

1.3 Testing and Inspection

Testing and Inspection shall be carried out according to the Specification and the relevant IEC Standards.

a) Type tests

PVC insulated Aluminium Service Wire with a proven design shall pass the type tests as per the IEC Standards, or equivalent Standard. Test certificates related to tests performed within last 5 years of bid closing date, may be accepted by the Employer.

b) Routine and Acceptance tests

During manufacture each batch of PVC insulated Aluminium Service Wire shall be subjected to the following tests conforming to the relevant Standards.

i) Mechanical strength of the conductor

ii) Insulation resistance

iii) Resistance to water ingress by capillary action

v) Dielectric strength

vi) Impulse (voltage) withstand

c) Acceptance tests

Acceptance tests may be witnessed by the Employer or his nominee and copies of the test certificates shall be supplied with the service wire. The following tests are to be performed

i) Performance of the PVC insulated Aluminium Service Wire under thermal/mechanical stress.

ii) Electrical resistance of phase and neutral conductors.

1.4 ELECTRICAL CHARACTERISTICS

a) Nominal Voltage
Nominal voltage of PVC insulated Aluminium Service Wire cables is 0.6/1 kV.

b) Dielectric Strength
PVC Service Wire shall be designed to withstand without breakdown the application of 10 kV for 30 minutes between cores and water.

c) Impulse Withstand Voltage
Conductors shall be designed to withstand, without breakdown, a standard impulse voltage sequence 1.2/50 μs of positive and negative polarity with a peak value equal to 20 kV.

d) Routine Test
Application of 4 kV for 15 minutes in water.

e) Rated Currents
According to IEC 60287.

1.5 CABLE CONSTRUCTION

The conductors shall be stranded, circular type.

PVC insulated Aluminium Service Wires shall generally comply with IEC 60502 in regard to the thickness of the insulation and the sheath.

The conductor cross sectional areas shall be 10 16 or 25 mm^2 as specified in the Price Schedule.

The Twin Service Wire with only one core insulated and both cores sheathed, shall have RED colour insulation for the insulated core and black colour overall sheath of the wire.

The quadruplex service wire shall have the three phase cores with RED, YELLOW and BLUE insulation and black sheath. The neutral wire sheath shall be BLACK.

1.6 MARKINGS

The outer sheath of the wire shall be embossed with letters "MEW" followed by the Manufacturer's identification at every 0.5m along the length of the wire.

1.7 PACKING

The wire shall be delivered in 100-500m coils wrapped in Polythene.

Each coil shall bear a tag under Polythene wrapping showing the Manufacturer's Name, Trade Mark, Type of Wire, Length of Wire and Insulation colour/colours.

2 ACCESSORIES

2.1 SCOPE

This scope covers the design, manufacture and testing of service wire tension clamp (dead end clamp) for PVC insulated stranded Aluminium Service Wires with Conductor cross section areas of 10 mm^2, 16mm^2 and 25mm^2.

The service wire tension clamp (dead end clamp) is the accessory that is used to support the service wire between the Low Voltage line pole and the Service Bracket on the consumer's house/building.

2.2 STANDARDS

IEC: International Electrotechnical Commission

- IEC 60207 Aluminum stranded conductors
- IEC 60208 Aluminum alloy stranded conductors
- IEC 60502 Power cables with extruded insulation for rated voltages from 1kV (Um=1.2kV) up to 30kV (Um=36kV)
- ISO 2063 Metallic coating-protection of iron and steel against corrosion

2.3 TESTING AND INSPECTION

Testing and Inspection shall be carried out according to the Specification and the relevant IEC Standards.

2.4 DESIGN

All accessories shall be suitable for the service wires specified.

All accessories shall be designed to meet the performance requirements of various sections of this Specification. They must be adequately rated for their intended application and retain this rating within their normal lifetime in an outdoor environment.

All accessories shall be free from defects which could cause them to be incorrectly assembled or to perform unsatisfactorily in service. Finish shall be such that outer surface are free of sharp edges and burrs which could result in damage to adjacent material or personnel.

Accessories comprising different component parts shall be designed so that they can be applied without disassembly. Installation of all accessories shall be possible by one man working alone.

2.5 MATERIALS

The materials used for manufacturing the fittings, accessories and apparatus covered by this Specification shall be compatible with the materials of the service wire.

Materials shall be resistant to climatic stress. All insulating materials shall be ultraviolet stabilized and coloured black. Steel parts shall be hot dipped galvanized, or stainless steel; other treatments are allowable if the protection against corrosion is equivalent to or better than hot dip galvanizing, subject to the Project Manager's approval. Other metallic parts shall be of non-corrosive materials.

2.6 MARKINGS

All Items shall be legibly and indelibly marked with:

- Manufacturer's logo or symbol
- Identification data
- Manufacturing code
- Standard

Special marking for connectors:

- Maximum and minimum section (in mm²) for main and tap conductor.

Special marking for pre-insulated junction sleeves and pre-insulated lugs:

- Position and order of compression (crimping)
- Removal length for insulation
- Groove index

2.7 SERVICE DEAD END CLAMP

Service Dead End Clamps shall be designed to anchor service wire with four and twin core aluminium service wires of size 10, 16 and 25mm². The clamps shall be of wedge type. They shall be made of mechanical and weather resistant material. No bolt for clamping the service wire and no loose parts are allowed. Also no special tools shall be required for installation of the clamp in the field. To ease the twisting movement involved in service wire, the clamp must be supplied with a flexible attachment into the above bracket by means of stainless steel flexible braid or hook.

Tests

All tests are to be conducted in accordance with the relevant IEC or equivalent Standards.

2.8 ANCHORING SERVICE BRACKET

Anchoring Service Bracket shall be used for anchoring service on the wall of consumer premises.

Design shall be suitable for installation by bolts, nails, or screws on a wall or a similar structure at the consumer's premises.

Working loads ≥ 2 kN.

2.9 ANCHORING PIG TAIL BOLT ON POLE

Pig tail bolt shall be used for anchoring service wire on pole by Service Dead End clamp.

It shall be steel galvanized and supplied with one nut and two washers.

Dimensions shall be:

- Diameter = 16 mm
- Length = 300 mm

Working loads ≥ 2 kN.

CHAPTER E

ACSR Conductors and Accessories

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ACSR CONDUCTORS AND ACCESSORIES

1 ALUMINIUM CONDUCTORS STEEL REINFORCED

1.1 Materials, Surface Conditions and Stranding

The aluminium wires used in the construction of the ACSR stranded conductors shall be made of best quality aluminum, smooth and free from irregularities. The galvanized steel wires shall be free of splices except those made on the base rod or wire before final drawing. These splices shall be made by resistance butt welding and shall be protected against corrosion.

All wires making up the conductor shall be free of spikes, sharp edges, abrasions or other imperfections, which would increase radio interference and corona losses. The conductors shall also be free from metal particles and dirt. The make-up and the laying of the conductor strands shall be such as to produce a conductor, free of a tendency to untwist or spring apart when cut. The stranding shall be such that, when subject to 50% of ultimate strength, there shall be no displaced wires, whilst maintaining a circular cross-section.

In all conductor construction, successive layers shall have opposite directions of lay, the outermost layer being right handed. Right handed lay and left handed lay shall be as defined in the latest edition of IEC 61089. The wires in each layer shall be evenly and closely stranded.

The lay ratios of different layers shall comply with the acceptable Standards.

The finished conductor shall be free from excessive amounts of manufacturing oil and other foreign deposits.

The particulars of the ACSR conductors and sizes to be supplied shall be as indicated in Chapter Y, Tables El-1 to El-3 of this section.

1.2 Standards

The conductors shall comply and be manufactured and tested in accordance with the following Standards:

IEC 60888	:	Zinc coated wire for stranded conductors
IEC 60889	:	Aluminum wire for overhead line conductors
IEC 61089	:	Round wire concentric lay overhead electrical stranded conductors
ISO 2063	:	Metallic coating-protection of iron and steel against corrosion
DIN VDE 48204	:	Aluminum conductor steel reinforced.

1.3 Inspection and Tests

The Employer or the Project Manager reserves the right to conduct inspections in the manufacturer's plant at any time during the manufacture of the conductors and to be present at the tests. The Contractor must inform the Employer and Project Manager as soon as possible of the dates and locations of these tests. In the factory, the manufacturer must provide all the resources needed to allow verification that all the requirements of the Specification are met.

The following tests are required for the conductors and accessories to the nominated IEC Standards:

- Type Tests
- Sample Tests

1.4 Type Test

The Employer may accept certified test certificates on standard products from a recognized testing laboratory, the tests being:

i) Joints in aluminium wires;

ii) Stress-strain curves;

iii) Breaking strength of the conductor.

1.5 Sample Tests

1.5.4 On wire before stranding

- as per the applicable wire standards.

1.5.5 On the conductor

- cross-sectional area;
- overall diameter;
- linear density;
- surface condition;
- lay ratio and direction of lay.

1.6 Drums

The conductors shall be delivered to sites on drums conforming to Standards, sufficiently strong and of sufficiently large drum diameter to provide protection against damage during shipping, handling and stringing operations. Drums should contain approximately equal lengths of conductor. Each drum shall be plainly labeled in a weatherproof manner; in addition to marks required for shipping purposes, each drum shall show the serial number, type of conductor, length of conductor (m), contract number, Employer's name, country of manufacture, arrow to show the direction of rolling and gross and net weights (kg).

Each drum shall be protected by wooden lagging on the circumference, of minimum thickness 40 mm.

2 CONDUCTOR ACCESSORIES

All conductor accessories and fittings have to be permanently marked (e.g. by punching) with the manufacturer's name or logo and the rated mechanical strength (KN). All steel parts are to be hot-dip galvanized. Care must be taken to eliminate the possibility of electrolytic corrosion.

The design of clamps to be used shall be such to reduce to a minimum the possibility of faulty assembly. Individual parts of clamps shall be interchangeable.

All bolts shall be captive and external nuts shall be locked in an approved manner. There shall be no relative movement within the clamp between individual layers of the conductor itself.

2.1 Compression Joint (Full Tension)

Mid-span joints of conductors shall be of the compression type exclusively. Each compression joint shall consist of a compression sleeve matching with the conductor material for the complete cable and aluminium or plastic plugs for sealing the holes in the sleeve ends; a viscous filler paste of an approved oxide inhibiting compound is to be injected into the sleeves. The filler compound shall be applied to exclude air or moisture. Each compression splice shall be capable of developing not less than 95 percent of the ultimate strength of the conductor and shall have conductivity not less than that of the conductor.

2.2 Repair Sleeves

Repair sleeves of the compression type, made of material compatible with the conductor material, shall be applied to reinforce and repair a conductor having several broken strands. No repair sleeves shall be placed on spans crossing roads, rivers or railways. The repair procedure is subject to approval by the Project Manager.

The conductor repair sleeves shall comply with relevant Standards specified and shall be suitable for use with conductors operating at a temperature of 70°C.

2.3 Line Tap "H Type" for Main Line Connection

This connector shall be "H" shaped Aluminum Compression Connector suitable for making line non-tension jumper connections and tee-off connections.

The connector shall be of one piece, suitable to accommodate conductors of equal and unequal sizes as indicated in the Schedule of Prices.

The die to be used shall be "O" type, "D" type or "N" type depending on the conductor size, type and type of compression tool (Mechanical/Hydraulic).

CHAPTER F

ABC Low Voltage Cables and Accessories

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1 CABLES

1.1 SCOPE

This Specification covers insulated aerial bundled cable (ABC) with aluminum phase core and aluminum alloy neutral messenger core, of nominal voltage U_0/U equal to 0.6/1 kV fitted with a cross-linked polyethylene insulating sheath, designed for use in low voltage OHL systems in urban areas.

The cross-sections of ABC are the following; for final quantities and cross-sections refer to the price schedules in Section VII:

- 3 x 120 mm² aluminum (phases) + 70 mm² alloy (neutral messenger) + 16 mm² (Street lighting wire)
- 3 x 95 mm² aluminum (phases) + 70 mm² alloy (neutral messenger) + 16 mm² (Street lighting wire)
- 3 x 50 mm² aluminum (phases) +35 mm² alloy (neutral messenger) + 16 mm² (Street lighting wire)

1.2 STANDARDS

IEC: International Electrotechnical Commission

IEC 60207	Aluminum stranded conductors
IEC 60208	Aluminum alloy stranded conductors
IEC 60228	Conductors of insulated cables
IEC 60502	Extruded solid dielectric insulated power cables

1.3 TESTING AND INSPECTION

Testing and Inspection shall be carried out according to the Specification and the relevant IEC Standards.

a) Type tests

ABC conductors with a proven design shall pass the type tests as per the IEC Standards.

b) Routine and Acceptance tests

During manufacturing, each batch of ABC shall be subjected to the following tests conforming to the Standards:

i) Mechanical strength of the conductor

ii) Insulation resistance

iii) Resistance to water ingress by capillary action

iv) Adherence of the insulating sheath on the conductor of the load bearing neutral core

v) Dielectric strength

vi) Impulse (voltage) withstand

c) Acceptance tests

In addition to the above tests:

i) Performance of the load bearing neutral core under thermal/mechanical stress.

ii) Electrical resistance of phase, neutral and street light conductors.

Acceptance tests may be witnessed by the Employer or his nominee and copies of the test certificates shall be supplied with the ABC.

F1.4 Electrical Characteristics

a) Nominal Voltage

Nominal voltage of ABC cables is 0.6/1 kV.

b) Dielectric Strength

Aerial bundled cables shall be designed to withstand without breakdown the application of 10 kV for 30 minutes between cores and water.

c) Impulse Withstand Voltage

Conductors shall be designed to withstand without breakdown a standard impulse voltage sequence 1.2/50 µs of positive and negative polarity with a peak value equal to 20 kV.

d) Routine Test

Application of 4 kV for 15 minutes in water.

e) Rated Currents

According to IEC 60287.

F1.5 Cable Construction

The conductors shall be stranded, circular type.

The load bearing neutral core conductor shall be aluminum-alloy with the following characteristics:

- Core strands of aluminum-alloy conforming to IEC 60208.

- Nominal diameter of strand : 3.1 to 3.5 mm
- Coefficient of linear expansion : 23 x 10-6 per °C
- Modulus of elasticity : 62 000 MPa.
- Minimum breaking load : 20 kN (for 70 mm² messenger)
- Minimum breaking load : 16 kN (for 35 mm² messenger)

The conductors, other than the load-bearing neutral core, shall consist of hard drawn aluminum.

Only the insulating sheath of conductors shall consist of XLPE. The neutral conductor (messenger) shall be without insulation.

For the load-bearing neutral core, a paper separator shall be applied over the conductor core.

F1.6 Markings

The markings are to be either indented or embossed, as follows:

All cables in a bundle shall carry the mark MWP at intervals of 1m in addition to any other markings.

The phase identification marking shall either be numerals or ribs; the number of ribs shall be easily identified by personnel.
One, two and three ribs are to be used to distinguish the three phase cores from each other, while the neutral shall have no ribs.

F1.7 Packing

The completed Aerial Bundled Conductors shall be delivered in continuous lengths of 500m + or –5%.

They shall be supplied in drums suitable for outdoors storage of two years.

F1.8 Maximum Permissible Temperatures

The maximum permissible temperatures of the conductors are as follows:

- 90 °C during normal operation
- 120 °C under a short duration overload (a total of 24 hours a year in separate periods of 3 hours maximum)
- 250 °C under multi-phase short-circuits conditions.

These temperatures are to determine the intrinsic properties of the insulating materials. These values can be used only for calculating permissible current ratings.

2 ACCESSORIES

2.1 SCOPE

The following accessories shall be used with the LV ABC network.

Single anchor assembly, load clamp, suspension assembly, insulation piercing connector, pre-insulated compression sleeve for main line and service ABC conductors, anchoring pig tail hook on wall, anchoring pig tail bolt on pole, anchoring service bracket, saddle for service and cable on pole, steel strap and buckle, insulated binding tie, insulation cap.

The bidder shall submit separately a list of suitable tools for using the accessories described here.

The price for tools shall be quoted in the relevant price sheets of Section VII, Schedule No. 1.

2.2 STANDARDS

IEC: International Electrotechnical Commission

IEC 60207	Aluminum stranded conductors
IEC 60208	Aluminum alloy stranded conductors
IEC 60502	Extruded solid dielectric insulated power cables
ISO 2063	Metallic coating-protection of iron and steel against corrosion

2.3 TESTING AND INSPECTION

Testing and Inspection shall be carried out according to the Specification and the relevant IEC Standards.

2.4 DEFINITIONS OF TERMS

The following are common terms used in this Specification.

- **Single anchor assembly**
  An eye bolt (pig tail hook) and a dead-end clamp designed to terminate main line conductor bundled cables and to transfer the tensile loading to the supporting structure.

- **Load clamp**
  A clamp designed to anchor ABC with a single anchor when the line deviation is > 45°.

- **Suspension assembly**
  A bracket and a clamp designed to support bundled conductors at intermediate positions and light angle positions (deviation < 30°).

- **Large angle.**
  When line deviation >30°, two single anchor assembl ies will be used with two load clamps.

- **Double anchor assembly**
  For a double anchor system, one eye bolt will be used with two load clamps.

- **Insulated facade saddle**
  A saddle designed to support an ABC cable or service at regular intervals on a wall or façade, which provides a secondary insulation for the bundled conductors.

- **Insulation piercing connector**
  A tap connector, to connect to the conductor of bundled conductors, through the insulation.

- **Pre-insulated compression sleeve**
  A Pre-insulated junction sleeve designed to joint ABC with other ABC. Neutral sleeve is full tension type.

2.5 DESIGN

All accessories shall be suitable for the whole range or part of the range of ABC, as well as for the conductor material used by the Employer, that is: 3 x 50 + 35N + 16 (street light), 3 x 95+70N + 16 (street light) and 3 x 120+70N mm² + 16 (street light) aluminum bundled. The bi-metallic service clamps shall be used for ABC service lines to meter boxes and/or meters as the case maybe by means of NYY-Cables ranging from 2 x 16 mm^2 up to 4 x 35 mm^2.

All accessories shall be designed to meet the performance requirements of various sections of this Specification. They must be adequately rated for their intended application and retain this rating within their normal lifetime in an outdoor environment.

All accessories shall be free from defects which could cause them to be incorrectly assembled or to perform unsatisfactorily in service. Finish shall be such that outer surface are free of sharp edges and burrs which could result in damage to adjacent material or personnel.

Accessories comprising different component parts shall be designed so that they can be applied without disassembly. Installation of all accessories shall be possible by one man working alone.

2.6 MATERIALS

The materials used for manufacturing the fittings, accessories and apparatus covered by this Specification shall be compatible with the materials of the ABC.

Materials shall be resistant to climatic stress. All insulating materials shall be ultraviolet stabilized and coloured black. Steel parts shall be hot dipped galvanized or stainless steel; other treatments are allowable if the protection against corrosion is equivalent to or better than hot dip galvanizing, subject to the Project Manager's approval. Other metallic parts shall be of non-corrosive materials.

2.7 MARKING

All Items shall be legibly and indelibly marked with:

- Manufacturer's logo or symbol
- Identification data
- Manufacturing code
- Standard

Special marking for connectors:

- Maximum and minimum section (in mm²) for main and tap conductor.

Special marking for pre-insulated junction sleeves and pre-insulated lugs:

- Position and order of compression (crimping)
- Removal length for insulation
- Groove index

2.8 ANCHOR ASSEMBLY

Each assembly includes:

- 1 bolt pig tail hook
- 1 wedge type dead-end clamp

a) Description

Description of sub-component of above assembly is as follows:

i) Eye bolt pig tail hook

Eye bolt shall be made of galvanized steel; supplied with one nut and two washers. Dimensions shall be:

- Diameter = 16 mm
- Length = 300 mm.

The hook point for clamps shall be 80 mm from pole.

ii) Clamp

Clamps shall be designed to anchor ABC with two sizes of neutral messengers (70 mm² and 50 mm²). The clamps shall be of wedge type. They shall be made of mechanical and weather resistant material. No bolt for clamping the neutral messenger and no loose parts are allowed. Also no tools shall be required for installation of the clamp in the field. To ease the twisting movement involved in ABC systems, the clamp must be supplied with a flexible attachment into the above bracket by means of stainless steel flexible braid or hook.

b) Tests

All loading tests shall be carried out with 70 mm² neutral messenger.

i) Clamp

Dielectric test
Tensile test
Slip test with tensile load and thermal stresses
Tension shock at low temperature

ii) Pig tail hook

Mechanical test

2.9 SUSPENSION ASSEMBLY

a) Description

Each assembly includes:

- 1 Suspension bracket made of aluminum alloy with a galvanized steel bolt;
- 1 Suspension clamp made of thermoplastic with no steel component.

Composition of sub-components of the above assembly is as follows:

i) Suspension bracket

The suspension bracket is made of aluminum alloy to be attached to all types of structures by one galvanized steel bolt.

The bolt shall be provided with one nut and two washers.

Bolt dimensions shall be:

- Diameter: 16 mm
- Length: 300 mm

ii) Suspension clamp and movable articulated link

The suspension clamp and articulated link is a device where no bolt for tightening the conductor and no losable parts are allowed. Clamping of the neutral messenger shall be by controlled slippage. This device must have the capacity for the suspension and tightening of messenger to 70 mm². Both suspension clamps and articulated link must be made entirely and exclusively of weather resistant material.

No bolt for clamping the neutral messenger and no losable parts are allowed; also no tool shall be required for installation of the clamp in the field.

Bracket and suspension clamp shall be specified together for compatibility between materials, to reduce all mechanical and weathering stresses.

b) Tests

i) Suspension clamp

Dielectric test
Tensile test
Slip test

ii) Suspension bracket

Mechanical test

iii) Suspension assembly tests

Fatigue test

2.10 INSULATED FACADE (WALL) SADDLE

a) Description

The saddles shall be used for securing ABC on walls. These saddles must be easily fixed onto a wall by means of a bolt or a plug screw. As saddles are to be supplied complete with the wall fixing item and the integral plug, the distance from the wall is required to be 10mm. The saddles shall secure ABC having outside diameters for: 3 x 120 + 70N +16 and 3 x 95 + 70N +16 Aluminium.

The saddle design must provide a secondary insulation between the conductor and a façade/wall or any metal part of the saddle attaching to the façade. The design must permit attachment to the façade/wall before the ABC is fixed in the saddle. The ABC will be fixed on concrete or wooden facades. The ABC must be releasable without removal of the saddles from the façade. The saddles shall have a second groove/clamp for installation of a second ABC without removal of the first cable.

The insulating saddle material must be ultraviolet stabilized, be black in colour, resistant to degradation due to pollution or weathering.

Exposed steel parts must be hot dipped galvanized or have an equal or better protective coating, subject to the Project Manager's approval.

The ABC shall be installed without special tools.

b) Tests

i) Dielectric test
ii) Mechanical test

2.11 INSULATION PIERCING CONNECTOR (IPC)

a) Description

Use of IPCs shall be for connection of service conductors to ABC network cables and tee-offs of main bundled conductors.

IPCs shall be a waterproof, high mechanical strength and climate resistant, insulated connector.
The connectors shall be insulated and suitable for installation on live or dead lines.

The IPCs shall not have loose components, which could be lost during installation. The housing shall be made entirely of mechanical and weather resistant plastic insulation material and no metallic part outside the housing is acceptable except for the tightening system. The housing shall be an integral part of the connector. The bolts shall include an over-torque shear head made of suitable material, which allows a clamping torque in conformity with the recommendation of the manufacturer, without the need for any special tool.

For safety, it is necessary that none of the energized parts of the connector can be touched by the operator during connector installation. IPCs shall be dielectrically waterproof in the same manner as the relevant cable. IPCs shall withstand 6 kV while immersed under water (300mm depth) for 1 minute. The number and the length of the teeth shall be adequate to penetrate the relevant bundled conductor insulation to establish proper contact with acceptably low contact resistance and without the need to strip the bundled conductor insulation. To achieve the required water-tightness, a special rubber seal shall be provided around the teeth of the connector. The bolt washers shall be of corrosion resistant type.

The current rating of the connectors shall be according to the rating of the specific cables matching the connectors.

Two types of connectors are to be supplied as follows:

i) Tee-off connector for main network ABC

ABC main and tap connectors shall be of insulation piercing type on the main conductor. The insulation shall be stripped on tap conductors and the tap conductors may be disconnected for easy fault location and operation. These connectors are applied with separate tightening.

ABC to ABC: Separate tightening.

Cross section main conductor: ABC 50mm^2 to 120 mm^2 Aluminum
Cross section tap conductor: ABC 50mm^2 to 120 mm^2 Aluminum

(ii) Tee-off connector for ABC service line to ABC network

ABC service connectors shall be of simultaneous insulation piercing type on main and tap conductors. These connectors shall have simultaneous tightening 1 bolt, 1 tap.

Application: Service ABC to Main ABC
Cross-section main conductor (ABC) 50mm^2 to 120 mm^2 (ABC) Aluminum.

Cross-section ABC tap: 40mm^2 to 50 mm^2 (ABC) copper.

Application: Service ABC to service ABC

Cross-section main service conductor (ABC): 10mm^2 to 50 mm^2 (ABC) copper

Cross-section service ABC tap: $10mm^2$ to $50\ mm^2$ (ABC) copper

b) **Tests**

i) Dielectric and water-tightness test
ii) Tensile test on main conductor
iii) Tensile test on tap conductor
iv) Installation test at low temperature

2.12 Pre-Insulated Junction Sleeve And Pre-Insulated End Lug

a) **Description**

The joints must be pre-insulated. The compression connection, directly made over the insulation by crimping, must not detrimentally affect the insulation of the sleeve or lug. The pre-insulated junction sleeve is to be dielectrically waterproof in the same manner as ABC and must withstand 6kV/50Hz for 1 minute, while immersed in water 300mm depth. For this purpose the pre-insulated sleeve and pre-insulated lug must be equipped with a rubber gasket. The pre-insulated sleeve and lug must be pre-filled with any suitable oxide inhibiting compound or silicone grease and the current rating of this equipment shall be equivalent to the respective cable. For easier identification pre-insulated sleeves and lugs must have markings indicating:

- The sequence and the location of hexagonal compression indents.
- The size of the die to be used.

The insulation stripping length must also be indicated on the joint. For easier identification on site, the section to be marked off shall be colour coded.

Sleeves and lugs must be crimped with regular hexagonal compression indents. The dies used are:

Section	***Groove (C)***	***Groove width***	***Groove index N°***
Less or equal to $25\ mm^2$ max external diameter = 16 mm	14 mm	5 or 9 mm	E 140
Superior to 25 and less or equal to $95\ mm^2$ Max external diameter = 22.9	17.3 mm	9 or 18 mm	E 173
Superior to $95\ mm^2$ Max external diameter = 26	21.5 mm	9 or 18 mm	E 215

The minimal output capacity of the hand hydraulic press must be:

Groove index N°	*Minimal output capacity (kN)* *Groove width*		
	5 mm	9 mm	18 mm
E 140	50	50	-
E 173	-	50	120
E 215	-	50	120

Pre-insulated sleeves used on the neutral messenger must match the full mechanical load of the messenger. Other sleeves may have reduced mechanical load.

Sleeves and lugs for main ABC network (3 x 120 + 70 N mm², 3 x 95 + 70 N mm² and 3 x 50 + 35 N mm²) must be supplied in a kit containing 3 phase sleeves and 1 neutral sleeve for the messenger.

b) Tests

i) Dielectric and water-tightness test of sleeves
(ii) Water-tightness test of lug
(iii) Corrosion test on aluminum/copper end lug
iv) Slip test

2.13 Anchoring Service Bracket

Anchoring Service Bracket shall be used for anchoring services on walls by clamps.
Design shall be suitable for installation by bolts, nails, or screws.
Working loads ≥ 2 kN.

2.14 Anchoring Pig Tail Bolt On Pole

Pig tail bolt shall be used for anchoring services on poles by clamps.
It shall be steel galvanized and supplied with one nut and two washers.
Dimensions shall be:

Diameter = 14 mm, Length = 300 mm
Working loads ≥ 2 kN.

2.15 Saddle For Service And Cable On Pole

This saddle shall be made of high mechanical and climate resistant insulating material and is to be used with existing stainless steel straps or new stainless steel straps.
The cable shall be fixed with a notched insulating tie.
The saddle shall hold 2- Cables up to 3 x 240 mm².

2.16 BUCKLES

Buckles shall be designed for tightening steel straps on poles. Buckles shall be stainless steel.
Dimensions shall be:

Width = 20 mm ,Thickness = 0.7 mm

2.17 INSULATED BINDING TIES

The binding ties shall be used for binding the cable at different locations with the dead-end clamp and suspension clamp. The strap shall be made of UV resistant thermoplastic having a tie capacity to suit ABC bundled conductors. The width of the strap shall be 20 mm, of lengths to suit the installations.

2.18 INSULATION CAP

The insulating cap shall be used at the terminations of the twisted insulated cable to avoid exposure to the atmosphere. The cap shall be black colour coated and of heat shrinkable type. All caps must be waterproof.

CHAPTER G

Distribution Transformers 15(20)/0.4kV

TABLE OF CONTENTS

1. SCOPE

This specification covers the design, manufacturing, testing, supply, delivery and performance requirements of 3 phase, 15(20)/0.4 kV, outdoor and indoor type Distribution Transformers

1.1 STANDARDS

The equipment shall comply with the latest editions and amendments of standards/specifications listed below:

IEC 60071	Insulation Coordination
IEC 60076	Power transformers
IEC 60137	Bushings for ac voltages above 1 kV
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60354	Loading guide for oil immersed transformers
IEC 60437	Radio interference test on high voltage insulators
IEC 60551	Measurement of transformer and reactor sound levels
ISO	International organization for standardization
ISO 2063	Metallic coating-protection of iron and steel against corrosion
ISO 1460	Testing of galvanization of iron and steel

The Supplier may propose alternative standards, as outlined in article 2.2 of Chapter B.

1.2 Testing and Inspection

1.2.1 General Notes for Tests

The transformers will be inspected and tested at the manufacturer's premises and the result of all tests will be sent to the Employer.

The inspection and tests listed hereinafter shall be carried out in accordance with the provisions in the relevant IEC recommendations.
The transformers shall be subjected to tests as specified below.

1.2.2 Type test

The following shall be regarded as type tests:

- Test of temperature rise (IEC 60076-2).
- Dielectric type Test (IEC 60076-3).

For submittal of type test certificates refer to Chapter B, Article 2.8.2.

1.2.3 Routine tests

The following shall be regarded as routine tests and shall be carried out on each transformer conforming to IEC standards:

- Measurement of winding resistance
- Measurement of Voltage ratio and check of phase displacement
- Measurement of short-circuit impedance and load loss
- Measurement of no-load loss and no-load current
- Dielectric Routine tests
- Tests on on-load tap changer, where appropriate

1.2.4 Special tests

The following Special tests may be required to be performed as per the request of the Project Manager

- Measurement of zero-sequence impedance(s) on three phase transformers
- Short-circuit withstand test
- Determination of sound levels
- Measurement of harmonics of the no-load current

2. PERFORMANCE CHARACTERISTICS

The 20 /0.4 kV transformers shall be double winding, three phases, oil immersed, 50 Hz and shall have off circuit tapings mounted in the primary winding. The type of cooling will be oil natural air natural (ONAN). The 15(20)/0.4 kV transformers shall be of hermetically sealed type.

The performance requirements are contained in the Technical Data Sheets of Chapter Y, Tables G.

2.1 Rated Power

The continuous rating of the distribution transformers shall be 100 kVA, 160 kVA, 250 kVA, 400 kVA and 630 kVA.

Each transformer shall be capable of supplying its rated power being the product of rated voltage and rated current on the line side winding (at center tap) expressed in kVA, as defined in IEC 60076-1.

The transformers shall also be capable of delivering rated current at an applied voltage equal to 105% of the rated voltage.

Likewise, each transformer shall be capable of supplying is rated power continuously under ambient temperature conditions without the temperature rise of the top oil exceeding 50°C and without the temperature rise of the windings as measured by resistance exceeding 55°C.

2.2 Overload Capacity

In addition, after thermal equilibrium has been reached at 75% of rated load, the transformers shall be capable of sustaining the overload conditions listed below, without the transformer winding hot spot temperature exceeding 140°C.

Load	***Minimum duration in minutes***	
Percentage of rated	Ambient temperature	Ambient temperature
Load	30°C	40°C
133%	240	115
150%	98	65

The Manufacturer shall include calculations demonstrating that these requirements are met. These calculations shall disregard the effect of winding thermal capacity.

Importance will be given to overload capacity, transformers incapable of meeting the specified performance shall not be considered.

2.3 Evaluation of Transformer Losses

2.3.1 Bid Evaluation and Purchase Price Cost Adjustments

The Employer shall factor the transformer life cycle total owning cost in the bid evaluation. The formula to be used is detailed in 2.3.2.

All delivered transformers shall have their value adjusted negatively if the average losses for all transformers of a specified size exceed the figures stated by the Contractor in the technical data sheets completed in Chapter Y Table G. If the average losses meet or better the expectation no adjustment shall apply.

2.3.2 Distribution Transformer Life Cycle Cost Calculations

A guarantee must be given that the transformer losses to be indicated in the technical data sheets are not exceeded. Penalising values for the losses are:

- Capital cost of no-load loss (A) : 8,250 US$ per kW
- Capital cost of load loss (B) : 3,570 US$ per kW

The bidder shall quote firm losses without any tolerance, which shall be used for the evaluation. Losses will be considered in bid evaluation using the following formula:

TOC = NLL x A + LL x B + C

Where:

TOC	=	capitalised total owning cost, $
NLL	=	no-load loss
A	=	capitalised cost of NLL
LL	=	load loss at the transformer rated load
B	=	capitalised cost of LL
C	=	the initial total purchase price of transformer, CIP without local taxes

In the event that losses measured during the factory tests exceed the guaranteed data, the penalising values shall be applied per kW in excess and be deducted from the transformer price.

On actual testing, if the losses are found to be higher than the quoted losses, a penalty at the rate of 200% above the mentioned rates shall be deducted for every kW of the excess loss and EXW purchase price adjusted. The Employer may choose to reject the transformer if losses exceed the quoted data by more than 10%.

3. TECHNICAL CHARACTERISTICS

3.1 Voltage Ratio

Each transformer shall be fitted with 5 taps giving provisions for off load changing of voltage ratio.

The no load voltage ratios shall be:

Tap number	*Primary voltage ±2 x 2,5 %*	*Secondary voltage*
1	21 000	400 V
2	20 500	400 V
3	20 000	400 V
4	19 500	400 V
5	19 000	400 V

3.2 Tapping Method

Tap changing shall be carried out with the transformer off load. An externally operated self positioning tapping switch shall be provided. Switch position No. 1 shall correspond to the primary voltage that gives the highest voltage ratio. Provision shall be made for locking the tapping switch handle, with a 6 mm standard diameter hasp lock.

The change switches shall be fitted with casketed covers so that sealing of the transformer under normal conditions will be independent of the switch shaft gland.

3.3 Winding Connections and Vector Group

The distribution transformers shall be connected in accordance with IEC 60076 as follows:

MV winding	:	delta connected
LV winding	:	Star connected
Vector group	:	Dyn 5

3.4 Insulation Levels

Power transformers shall be designed and tested to the following insulation levels:

Phase and natural terminals	*Power frequency voltage (rms.)*	*Lightning impulse voltage (peak)*
20 kV	50 kV	125 kV (1.2/50μs)
0.4 kV	3 kV	N/A

The windings shall be fully insulated and the neutral point shall be insulated for full voltage.

For the transformer windings, thermally stabilized paper shall be used. Minimum percentage retention when tested as per ASTM D202 in oil at 150° C shall be as follows:

Days in oil	*Minimum percentage retention*
10	90%
30	75%
50	60%
180	32%

3.5 Impedance Voltage

The impedance on the principal tap (tap 3) shall be 4% for the distribution transformers of 63 kVA to 400 kVA and 6% for the distribution transformers 630 kVA and 1000 kVA and it shall be subject to the tolerance specified in IEC 60076.

Transformers shall have corresponding impedance per tap characteristics such that transformers of the same rating can be operated in parallel.

3.6 Short Circuit Performance

Each transformer shall be capable of withstanding for 2 seconds a metallic short circuit on the terminals of either winding with rated voltage on the other winding and the tap changer in any position.

3.7 Regulation

The supplier shall guarantee that the regulation of each transformer from no load to continuous rated output at 1.0 power factor and at 0.85 lagging power factor shall be as stated in the technical data sheets.

3.8 Over Fluxing

The distribution transformers shall be capable of operating continuously with rated current and with system maximum voltage applied to the secondary winding at a frequency of 96% of rated frequency without exceeding the temperature rise.

The transformer shall withstand without injurious heating overfluxing condition 125% for 1 min and 140% for 5 seconds.

For all transformers, the limit of flux density at any point in the magnetic circuit shall be subject to the requirements for losses, harmonics and noise suppression.

3.9 Partial Discharge

Partial discharge level shall be:	Less than 50% at 24 kV Less than 100 % at 28.8 kV (1.2 Un)

3.10 Noise Level

Maximum allowable noise level at 0.3 meters measured in accordance with IEC 60551.

4. MATERIALS AND CONSTRUCTION

4.1 TANK

The transformer tank shall be designed so that the completed transformer can be lifted and transported without permanent deformation or oil leakage.

The tank and cover shall be designed in such a manner to leave no external pockets in which water can lodge.

All pipes, radiators, fins or corrugation shall be external welded to the thank wall.

Each transformer shall be provided with a minimum of two closed lifting lugs. The minimum diameter or the hole or width of the slot shall be 25 mm. The two lifting lugs shall be located such that there will be a minimum of 50 mm between the lifting chain and the nearest part of the bushings.

All transformers shall be suitable for outdoor mounting and shall have four mounting lugs with 12 mm diameter holes suitable for bolting the transformer to the platform.

A satisfactory lid sealing gasket shall be provided on each transformer to maintain the seal against extremes of operating temperature. A cold oil level mark shall be provided inside each transformer marked C.O.L.

4.2 Core and Coils

The primary and secondary windings shall be made of high conductivity copper.

The core and coil assembly shall have the core and coils rigidly connected to the tank and suitable closed lugs shall be provided for removing the core and soil assembly from the tank.

4.3 Surface Treatment

The transformer tank and accessories shall be adequately protected against corrosion and the supplier shall include a statement on the proposed method of protection. The transformer tank and its steel attachments shall be galvanized or metallized, followed by painting to a minimum thickness of 50 microns. Sufficient pretreatment of the zinc surface should be carried out as necessary in order to guarantee long life adhesion. The weather proof ability of the paint used should be proven and documented.

The inside of the tank shall be painted with an approved oil resisting varnish.

~~The out side of the tank shall be painted grey color.~~

4.4 Primary Bushings for Outdoor Type Transformers

All winding leads shall be brought out through bushings. All bushings shall be so designed that there will be no excessive stressing of any parts due to temperature changes and adequate means shall be provided to accommodate conductor expansion.

The insulation levels for bushing shall be at least equal to those specified for the windings.

The creepage distances for the bushings and the insulators shall not be less than 25 mm/kV.

The porcelain shall be tested according to IEC Publication 233 or equivalent DIN standard respectively. The glaze shall be brown and shall cover all exposed parts of the insulator. Between the porcelain and surrounding metal, gaskets or cement is to be interposed. All porcelain clamping surfaces in contact with gaskets shall be accurately grounded and free from glaze.

Each porcelain bushing shall be marked with manufacturer's identification mark, indicating the date of manufacturing and other marks necessary for the tests. The marking shall be clearly legible and visible after assembly of the fittings.

Connections from the windings to the bushings shall have necessary flexibility.

Clamps and similar details made of steel or malleable iron shall be galvanized.

The fittings (lugs and rods) shall be made of copper or bronze.

External terminals shall comply with the requirements of High Voltage Terminals.

Copper or copper alloy terminals shall be tinned to a thickness of minimum 50 µm.

Copper alloys shall not be sensitive to cracking.

The bushings shall be so installed that they are easy to be checked and removed without removing the tank cover and the pipe work.

4.5 Primary Bushings for Indoor Type Transformers

Indoor Distribution Transformers installed in compact substations require a connecting design with screened separate connectors on power cables and cone plug-in bushings on equipment because of the reduced distance between transformer and enclosure of the compact substation.

Such connections render a more compact building construction, are floodable, maintenance free, and protect the cable against environment influences.

The following specification applies to MV cone plug-in bushings installed on transformer and MV screened separable connectors for MV cables.

Distribution transformer shall be supplied equipped along with Plug-In Bushings on 24kV side.

Complete specification of screened separable connector and Plug-in bushing equipment is described in Chapter H, Compact Substations.

4.5.1 Electrical Characteristics

Rated Voltage Ur
The rated voltage of plug-in bushings and screened separable connectors shall be 24kV.

Rated currents Ir
The rated current of plug-in bushings and screened separable connectors for Distribution Transformer shall be 250 A.

Rated short-time withstand voltage for power frequency
The plug-in bushings and screened separable connectors defined in this specification shall have a rated short time withstand voltage for power frequency of 50 kV (rms)/1minute.

Rated impulse withstand Voltage
In accordance with IEC recommendations, the plug-in bushings and screened separable connectors defined in this specification shall have a rated impulse withstand Voltage of: 125 kV peak (1.2/50 µs wave).

4.6 Secondary Bushings

4.6.1 General

Distribution transformer shall be supplied with porcelain bushings on LV side.
Secondary bushings include porcelain insulator and copper terminal.

4.6.2 Electrical Characteristics

Rated voltage = 1 kV
Withstand voltage at power frequency 50 Hz = 10 kV (1 mm, wet)
Rated impulse withstand voltage = 30 kV (1.2/50 μs)

4.6.3 Description

Each terminal shall be suitable to receive up to n x 1 x 240 mm² copper cable lugs, according to the rated capacity of the transformer.

For indoor type transformers, terminal lugs for LV cables shall be provided for Compact Substations.

4.7 Terminal Marking

The terminal markings shall be clearly and permanently displayed. Painted markings are not acceptable.

The distribution transformers shall be labeled as follows:
Primary voltage: A, B, C – also acceptable 1U, 1V, 1W
Secondary voltage: a, b, c and n – also acceptable 2u, 2v, 2w

4.8 Label and Rating Plates

Labels, plates, markings and instructions shall be clear and indelible and in the English language. Case-in or molded-in words which are not English words shall be covered with permanently fixed non-ferrous labels inscribed in English.

A weatherproof rating plate shall be provided in accordance with IEC 60076 and showing the following items, indelibly marked:

- Type of transformer,
- Specification to which standard it was manufactured,
- Manufacturer's name,
- Serial number,
- Year of manufacturer,
- Number of phases,
- Rated power
- Rated frequency
- Rated voltage

- Rated currents
- Vector group
- Percentage impedance voltage at rated current
- Type of cooling
- Continuous ambient temperature at which ratings apply
- Top oil temperature rise at rated load
- Total weight
- Volume of oil
- ~~Weight of core and windings~~
- Employer's name
- Table of primary voltages at the 5 tapping positions
- Connection diagram

4.9 OIL

All transformers shall be filled to the required level with new, unused, clean, standard mineral oil in compliance with IEC 60296 and shall be free from all traces of polychlorinated biphenyl (PCB) compounds.

CHAPTER J

Part I: Pole Mounted Load Break Switch
Part II: Indoor Mounted Load Break Switch

TABLE OF CONTENTS

I. POLE MOUNTED LOAD BREAK SWITCH

I.1. SCOPE

This specification is applicable to 24 kV three phase pole mounted load break switch, intended for outdoor use.

I.2. STANDARDS

This equipment shall comply with the latest editions and amendments of standards/ specifications listed here after.

IEC 60050	*International Electrical Vocabulary – IEV*
IEC 62271-100	*High voltage Alternative current circuit breakers*
IEC 60059	*IEC standard current ratings*
IEC 60071.1	*Insulation coordination- Part 1 Definition, principles and rules*
IEC 62271-102	*Alternating current disconnectors and earthing switches*
IEC 60265-1	*High voltage switches part 1 High voltages switches for rated voltage above 1 kV and less than 52 kV*
IEC 60694	*Common specifications for high voltage switchgear and control gear standards*

I.3. TESTING AND INSPECTION

Testing and Inspection shall be carried out according to General Specification.

This equipment shall be inspected at the manufacturer's factory.

The inspection and tests listed hereafter shall be carried out with the provisions in the relevant IEC recommendations.

I.3.1 TYPE TESTS

For type test certificates refer to article 2.8.2 of Chapter B. The following test shall be carried out as per IEC 60265:

- Dielectric test
- Radio interference voltage (RIV) tests
- Measurement of the resistance of the main circuit
- Temperature-rise tests

- Short-time withstand current and peak withstand current tests
- Verification of the protection
- Tightness tests
- Electromagnetic compatibility (EMC) tests
- Making and Breaking tests
- Mechanical operation tests
- Operation under severe ice conditions

I.3.2 ROUTINE TESTS

The Routine tests shall be carried out in accordance with IEC 60694, clause 7.
Tests to be carried out:

- Dielectric test on the main circuit
- Tests on auxiliary and control circuits
- Measurement of resistance of the main circuit
- Tightness test
- Design and visual checks

I.4. TECHNICAL CHARACTERISTICS

I.4.1 RATINGS

The pole mounted Load Break Switch is designed to be used in outdoor service conditions.

○ Rated Voltage:	24 kV
○ Operating voltage:	20 kV
○ Rated impulse withstand voltage (1.2/50µs wave)	
- Phase to Earth:	125 kV peak
- Across the insulating distance:	145 kV peak
○ Rated power frequency. withstand voltage (kV rms)	
- Phase to Earth:	50 kV rms
- Across the isolating distance	60 kV rms
○ Rated frequency:	50 Hz
○ Rated normal current:	630 A
○ Rated short time withstand current	12.5 kA rms/ 1s
○ Rated mainly active load-breaking current	630 A

- Rated closed loop breaking current 630 A
- Rated no load transformer breaking current 2.5 A
- Rated line charging breaking current 10 A
- Rated short circuit making current 31 kA

The mechanical endurance of load break switches shall ensure at least 1000 on / off operations.

The electrical endurance of load break switches shall ensure at least.

- 2 making operations at rated short circuit making current without maintenance
- 400 making and breaking operations at rated breaking current without maintenance

I.5. MOUNTING ARRANGEMENT AND FABRICATION

I.5.1 GENERAL

The load break switch shall be suitable for installation on pre-stressed steel concrete poles with vertical, horizontal and triangular conductors lay out options.

They shall be supplied complete with galvanized steel brackets, bolts, nuts and washers for mounting on a concrete pole.

I.5.2 FRAME

The load break switch frame shall be provided to be installed non insulated from a pole. One hole shall be provided for earthing connection.

I.5.3 CONNECTION

Suitable terminals / connectors to be provided for accommodating Al / Cu conductors ranging from 35 mm^2 to 240 mm^2.

I.5.4 DEGREE OF PROTECTION

Except for insulating support, if the switch includes an envelope or a tank, the degree of protection of this envelope shall be IP 4 X.

I.5.5 BREAKING AND DISCONNECTING

The breaking chamber of the switch shall be SF_6 gas-immersed type. The SF_6 breaking chamber shall be sealed for life and "sealed pressure system" in accordance with IEC 60694 with a service life at least 30 years. The pressure inside the tank shall be less or equal to 1.3 bar. No refilling of the gas shall be required over this period. The SF_6 used shall be new in accordance with IEC 60376 requirements.

I.5.6 DISCONNECTING

The disconnecting function shall be carried out when the separation of the main contacts is certain. It will be certain when a position indicator shall be shown by reliable indication device directly connected to the movable contacts. The position indicator mechanism shall be simple, robust, and it shall give a true reflection of the main contacts. This reliable indicating device shall be in accordance with IEC 62271-102.

I.5.7 INSULATORS AND BUSHING

The load break switch shall be supplied with insulators or bushings made of polymer or porcelain. Parts carrying heavy current shall be made of copper or copper alloy.

I.5.8 CREEPAGE DISTANCE

The minimum creepage distance shall be 25 mm/kV.

I.5.9 OPERATING MECHANISM

Down-rod to be supplied for manually switching from the ground level (approx. 8 m high)

Each type of load break switch shall be suitable to be remote control with a SCADA system.

I.5.10 NAMEPLATES

Switches and their operating devices shall be provided with nameplates which contain information in accordance with the following table.

	Abbreviation	*Unit*	*Switch*	*Operating device*	*Condition*
Manufacturer			x	x	
Designation of type and class			x	x	
Serial number			(x)	(x)	
Rated voltage	Ur	kV	x		
Rated impulse withstand voltage	Uw	kV	x		
Rated frequency	fr	Hz	x		
Rated normal current	Ir	A	x		
Rated short time current	Ik	kA	x		

Rated duration of short time current	tk	s	(x)	If different from 1s
Rated short circuit making current	Ima	kA	(x)	
Rated mainly active load breaking current	I 1	A	(x)	
Rated distribution line closed-loop breaking current	I 2a	A	(x)	
Rated no load transformer breaking current	I 3	A	(x)	
rated cable charging breaking current	I 4a	A	(x)	
Rated line charging breaking current	I 4b	A	(x)	
Rated gas pressure for SF_6	Paw	Pa	(x)	

x The marking of these values is mandatory : blanks for these values indicate the value 0

(x) The marking of these values is optional

I.5.11 PROTECTION AGAINST CORROSION

The units shall be weatherproof in the climatic conditions defined in General Technical Specifications of Chapter B.

Metal and steel parts shall be protected or self protected against corrosion.

The tank of the load break switch shall be made of stainless steel, galvanized steel or aluminum alloy and strong enough to support dynamic short circuit forces and the vibration of the switch.

I.5.12 INSTRUCTIONS

One installation and operating instruction book shall be delivered with each load break switch.

II. INDOOR MOUNTED LOAD BREAK SWITCH

II.1 SCOPE

This specification is applicable to 24 kV three phase load-break switches intended for use of the indoor transformer substations.

II.2 STANDARD

This equipment shall comply with the latest editions and amendments of standards listed here after.

IEC 60071.1	Insulation Coordination, Part. 1, Definition, principals and rules
IEC 60265.1	High voltage switches Part 1, for rated voltages above 1 kV and less than 52 kV.
IEC 60273	Characteristics of indoor and outdoor post-insulators for systems with voltages above 1000 V.
IEC 60694	Common clauses for high voltage switchgear and control gear standards.
IEC 62271-100	High voltage alternating current circuit breakers
IEC 62271-102	Alternating current disconnectors and earthing switches

II. 3. TESTING AND INSPECTION

Testing and Inspection shall be carried out according to General Specification.

This equipment shall be inspected at the manufacturer's factory.

The inspection and tests listed hereafter shall be carried out with the provisions in the relevant IEC recommendations.

II.3.1 TYPE TESTS

- Dielectric test
- Radio interference voltage (RIV) tests
- Measurement of the resistance of the main circuit
- Temperature-rise tests
- Short-time withstand current and peak withstand current tests
- Verification of the protection

- Tightness tests
- Electromagnetic compatibility (EMC) tests
- Making and Breaking tests
- Mechanical operation tests

II.3.2 ROUTINE TESTS

The following routine tests conforming to IEC 60694 shall be carried out during the Manufacture. Extra copies of these Test Certificates shall also be supplied with the equipment.

- Power frequency voltage withstand tests
- Measurement of the main circuit resistance
- Mechanical operating test
- Tightness test
- Design and visual checks

II.3.3 ACCEPTANCE TESTS

Following acceptance shall be carried out.

- Dielectric tests on the main, auxiliary and control circuits
- Measurement of the contact resistance
- Mechanical Endurance Test
- Making and Breaking Test
- Fault Making Test

II.4. TECHNICAL CHARACTERISTICS

II.4.1 RATINGS

The pole mounted Load Break Switch is designed to be used in outdoor service conditions.

Rated Voltage:	24 kV
Operating voltage:	20 kV
Basic impulse level	125 kV
Rated power frequency test voltage	50 kV
Rated frequency	50 Hz

- Rated normal current 630 A
- Rated short time withstand current 13 kA
- Load breaking current (20 operations) 630 A
- Load breaking current (200 operations) 30 A
- Close loop current 630 A
- Inductive breaking current 15 A
- Capacitive breaking current 20 A
- Rated short time withstand current 12.5 kA rms/ 1s
- Rated short circuit making current 31 kA

II.5 MOUNTING ARRANGEMENT INDOOR

II.5.1 GENERAL

The load break switch shall be suitable for wall mounting as shown on drawings H-09 and H-10 of Chapter Z-3.

They shall be supplied together with busbars, and mounting frame for indoor use. The cast resign insulator shall be mounted on a galvanized sheet steel base plate. Supply and installation include all accessories like cable termination, fuse base, H.R.C. fuses, clamp plates, bolts, nuts and washers.

The load break switch shall be light weight and robust.

The mechanical design and strength of the unit and components shall be able to bear the mechanical forces on the switch terminals when installed and on operation. They should withstand the electrodynamics forces without reduction of reliability or current carrying capacity of the switches.

II.5.2 INSULATORS

The solid core type post insulator support shall be of high quality insulating porcelain or cast resin utilizing clean aero-dynamic sheds giving extended creepage distances and excellent performance even under conditions of heavy atmospheric pollution.

The total creepage distance and the protected creepage distance (if applicable) shall be as stipulated in Chapter B.

II.5.3 STATIONARY AND MOVING CONTACTS

All castings for fixed and moving contacts, terminal pads shall be of Phosphor Bronze or Hard Drawn Copper or Silver coated Electrolytic Copper.

The contact surface shall be made out of silver plated hard drawn copper, and shall be mounted on Phosphor bronze castings or any other harder metals which does not deteriorate for prolonged electric arc.

The stationary contacts shall be backed by stainless steel pre-stressed compression springs with multi finger contacts to provide the required contact pressure, resulting in minimum electrical resistance.

The advantage of the electro-magnetic forces created by a fault current to increase the contact pressure where most needed at the contact shall be incorporated in the design of the stationary contacts.

II.5.4 TERMINALS

Clamp type terminals, made of phosphor bronze castings and silver plated shall be provided to accommodate 50 to 240 mm^2 copper conductors.

II.5.5 LOAD INTERRUPTION

The load interruption shall take place within the interrupter head without an external arc or flame conforming to IEC 60265, Category A. Electronic controlled arc interrupters is not acceptable.

The load interruption shall be achieved by providing a parallel circuit for re-directing the load current path from the main isolator contacts at the instant of their separation. The design of the equipment shall allow the replacement of load interrupter head after a specified number of operations. The manufacturer shall indicate the number of load break operation possible without changing the interrupter head.

The inner layer of the arcing chamber shall be suitable for generating arc-quenching-gas. The generated de-ionized gas shall extinguish the arc and be dissipated through a rear exhaust chamber, well clear of the switch.

The internal contacts shall be spring loaded and be of such design as to provide a positive and independent tripping action.

The interrupter contacts shall not be in the main current path when the main contacts are in a fully closed position.

The load interrupter head shall be designed to prevent leakage of water to the arcing chamber (where the control mechanism including the spring for opening and closing is housed) and be made of non corrosive materials.

II.5.6 Operating Mechanism

Manually independent spring loaded closing and opening operations have to be incorporated in the Load Breaker operating system.

Load break switches shall be supplied for vertical mounting.

The complete operating mechanism with operating handle shall be arranged for steady hand operation.

The bearings of the rotating mechanism shall be permanently sealed, corrosion proof, be of anti-friction type and shall be free from maintenance.

All bolts and nuts to conform to the standard specified. The nuts and heads of all bolts to be of hexagonal type.

All steel part shall be hot dip galvanized.

The vertical drive tube shall be provided with an Insulator, to withstand the rated voltage at a height of two meters above the operating mechanism for the safety of the operator. This insulator shall be suitable to withstand the operating forces.

II.5.7 Galvanizing

Unless otherwise specified all iron and steel parts shall be galvanized after the sawing, shearing, drilling, punching, filling, bending and machining operations.
All required materials shall be hot dipped galvanized to comply with the relevant specifications for galvanizing.

All iron and steel components shall be effectively galvanized to consist of a coating not less than 610 mg of zinc per square meter of surface and the components shall have a galvanized coating of uniform thickness not less than 0.086mm.

All threaded sections shall have a coating of at least 493 mg of zinc per/square meter.

The galvanized coating on all items shall be smooth, continuous, uniform and free from flux stains and holes shall be free from nodules of spelter.

All galvanized items shall be treated with Sodium Dichromate solution after galvanizing to prevent the formation of white rust.

II.5.8 RATING PLATE

The rating and data of the load break switch shall be engraved or embossed on a weather and corrosion proof metal plate. The rating plate containing the following information shall be positioned at the base supporting frame of the post insulator and shall be prominently visible.

- Manufacturer's Identification (Trade Mark)
- Country and Year of Manufacture.
- Designation of Type, Class etc.
- Rated voltage and frequency (kV & Hz)
- Rated power frequency withstand voltage (kV)
- Basic impulse level (kV)
- Rated nominal current (A)
- Rated short circuit making current (KA)
- Rated short time (1 sec.) current (KA)
- Total net weight (kg.)

II.5.9 PACKING

Each unit shall be securely and individually packed in a wooden box suitable for overseas shipment to a tropical country and to withstand rough handling. Each packing shall contain a copy of Installation Instruction and Erection Drawings and Maintenance Instruction in English Language.

Each packing shall be clearly marked with the following:

- Name of Item
- Rated Voltage
- Rated Current
- Manufacturer's Name and Identification mark
- Country of Origin
- Gross weight

Chapter K

Medium Voltage Switch-Fuse Combination

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MEDIUM VOLTAGE SWITCH-FUSE COMBINATION

1. SCOPE

This specification covers the general requirements of design, manufacture and testing of medium voltage 24 kV Switch-fuse Combinations for protection and isolation of medium voltage indoor distribution transformer substations of Dasht-i-Barchi Project area.

1.1 SWITCH

The Switch shall be of three phase type suitable for providing Medium Voltage side isolation for the indoor type distribution transformer substations with transformer capacities from 400kVA to 630kVA.

1.2 FUSE HOLDER

Fuse holders shall be mounted on the elongated base frame of the Switch. It shall accommodate three fuse links (fuse carriers) on epoxy resin insulators for the three phases.

1.3 FUSE LINK

The fuse links are required to give protection against short circuits. They shall be compatible with the fuse holders. They shall be so rated and shall have such characteristics as to be suitable for selective operations with the fuse links at present in use on the system namely Type K; i.e., fast (NEMA SG2).

2. STANDARDS

The equipments and the components supplied shall be in accordance with the latest edition of the standards specified below and amendments thereof.

IEC		**International Electrotechnical Commission**
○	IEC 60420 :	High Voltage Alternating Current Switch-fuse Combinations
○	IEC 60694 :	Common Specifications for high voltage switchgear and control gear standards
○	IEC 60282-1 :	High Voltage Fuses Part 1: Current Limiting Fuses
○	IEC 60787 :	Selection of High Voltage Current Limiting Fuse Links for Transformer Circuits
ANSI		***American National Standards Institute***
○	ANSI C37-42:	Melting Currents for Type K (fast) Fuse Links

3. TESTING AND INSPECTION

All switch-fuse combinations offered in this document shall have been fully tested in accordance with the practices and tolerances indicated in the General Specification. This equipment shall be inspected at the manufacturer's factory.

Test certificates shall be submitted.

The Routine tests shall be carried out in accordance with IEC Standards.

3.1 TYPE TESTS

The following tests shall be carried out:

- insulation level tests
- temperature rise test
- rated peak withstand current and rated short-time withstand current tests
- making and breaking capacity
- mechanical function of the switching devices and of the detachable switchgear parts
- contact protection against live parts and moving parts
- protection of personnel against dangerous electrical effects (discharge currents)

3.2 ROUTINE TESTS

Tests to be carried out:

- power-frequency test
- voltage test
- resistance test of the circuit
- mechanical function test
- test of the auxiliary equipment
- verification of the wiring

4. TECHNICAL CHARACTERISTICS

The technical characteristics are to be found on table K-1 of Chapter Y, Technical Data Sheets.

5. DESIGN AND CONSTRUCTION

5.1 DESIGN

The switch-fuse combination shall be supplied complete with galvanized steel brackets, bolts, nuts and washers for fixing of cables to the combination switch terminals as well as for mounting on the wall of indoor distribution transformer cubicle or similar structure.

The switch-fuse combination shall be of three phase type, suitable for indoor use. It shall be used for isolating distribution substation from the energized sections and shall be of the single /double break type isolation with manual gang operated mechanism.

The continuous current rating and the short time thermal current rating/duration of the switch-fuse combination shall be as stipulated in Table K-1 of Chapter Y. The switch-fuse combination shall be able to disconnect the normal full currents of transformers with capacities from 160kVA to 630kVA and necessary replaceable auxiliary arcing contacts shall also be provided.

Fuse holders for the three phases shall also be mounted on the same bracket as the switch-fuse combination together with all necessary internal connections between the switch and the fuses.

The fuse link shall have current characteristics, generally in accordance with NEMA SG2 Class K. It shall be capable of accepting IEC/NEMA fuse elements from 4 A up to a maximum continuous current rating of 80 A.

The manufacturer shall provide time-current characteristics of all the distribution fuse links in the offer. The performance characteristics of the fuse links shall include melting time-current characteristics.

The manufacturer shall state the minimum and maximum melting currents required to melt the fuse links at the three appropriate time points used in table 6 of ANSI C37.42.

5.2 CONSTRUCTION

The construction of the whole unit complete with adjustable support brackets, clamp plates, bolts, nuts and washers shall be compact, light weight and robust. The minimum distance between phase centres shall be as stipulated in Table K-1 of Chapter Y.

The mechanical design and strength of the unit and components shall be able to bear the mechanical forces on the terminals when installed and on operation. They should withstand the electrodynamics forces without reduction of reliability or current carrying capacity of the switch-fuse combination.

The switch-fuse combination insulators incorporating the breaking arm shall be securely fixed to the phase coupling bar so as to achieve a positive closing or opening operation of the three phases simultaneously.

The fuses shall be on the downstream of the switch. The three phase switch and the fuses for the three different phases shall be mounted on the same frame.

The switch-fuse combination shall be equipped with a fuse tripping mechanism or any other suitable load interruption mechanism for interrupting the normal full load current of distribution transformers with capacity from 160 to 630kVA.

The arc shortening rod of fuse link, shall be permanently attached to the fuse link cap. Fuse link material shall preferably include fibreglass.

All current carrying parts of the fuse links shall be of non-ferrous material, the main requirement being resistance to atmospheric corrosion. Tin is not acceptable for the fuse link.

5.3 INSULATORS

The insulators shall be of solid core post type made either of high quality insulating porcelain or polymer. The total creepage distance shall be as specified in Table K-1 of Chapter Y. The end of the main insulator shall be supplied with 2 end fittings which can be connected with other line fittings.

5.4 CONTACTS AND TERMINALS

The fixed and moving contacts shall be made out of copper alloy and the contact surface shall be silver plated. The fixed contacts shall be fitted with stainless steel compression springs to provide the required contact pressure.

5.5 OPERATING MECHANISM

It shall be suitable for manual operation with padlocking facilities only in the fully opened or fully closed position.

The operating mechanism shall be suitable for left hand or right hand mounting of the structure. The direction of operation, ON and OFF position shall be clearly and indelibly marked on the switch-fuse combination operating mechanism.

The complete operating mechanism with operating handle shall be arranged for steady hand operation from ground level. Non ageing and UV treated insulation shall be provided to the holding parts of the operating handle for safety.

The bearing of the mechanism shall be of permanently sealed corrosion proof, anti-friction type and free from maintenance.

All bolts and nuts to conform to the standards specified. The nuts and heads of all bolts shall be of hexagonal type.

5.6 ADDITIONAL REQUIREMENTS

5.6.1 Rating Plate

The rating and data of the switch-fuse combination shall be engraved or embossed on a weather and corrosion proof metal plate. The rating plate containing the following information shall be positioned at the base supporting frame of the post insulator and shall be prominently visible.

- Manufacturer's identification
- Country of Manufacture and Year of Manufacture
- Number and the Year of the standard adopted.
- Designation of Type, Class etc. and Serial Number
- Rated Voltage and Frequency (kV & Hz)
- Rated 1 minute power frequency withstand voltage (kV)
- Rated lightning impulse withstand voltage (kV)
- Rated continuous current (A)
- Rated short time withstand (1 sec.) current (kA)
- Rated mechanical terminal load (N)
- Weight (kg)

For galvanizing, quality assurance and packing refer to the general technical specifications of Chapter B.

Appendix C

Medium and Low Voltage Distribution Network Standard Technical Specifications

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CHAPTER L	–	I. Fuse Cut Out / MV Fuse Link and II. Load Break Fuse Open
CHAPTER M	–	MV Capacitor Banks and Accessories (Not Included)
CHAPTER N	–	Low Voltage Distribution Switchboards
CHAPTER O	–	Meter Boxes with MCB, Single and Three Phase Meters
CHAPTER P	–	Surger Arresters
CHAPTER Q	–	Medium & Low Voltage Insulators and Accessories
CHAPTER R	–	Medium Voltage Recloser
CHAPTER S	–	Part 1: Pre Stressed Steel Concrete Poles Part 2: Acceptance Test of Concrete Poles Part 3: Galvanized Steel Cross Arm Assembly

CHAPTER L

Part I: Fuse Cut Out / MV Fuse Link
Part II: Pole Mounted LV Switch Fuse Cut-out

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I. FUSE CUT OUTS / MV FUSE LINKS AND RELATED ITEMS

I.1. SCOPE

Pole-mounted three phase, fuse cut-out and fuse link units shall be supplied to protect and provide isolation for distribution transformer circuits and to medium voltage spurs.

I.1.1 FUSE CUT-OUT

Fuse links for the 20kV fuse cut-out units shall be of the disconnecting type suitable for opening, closing and removal by an operating stick. The rated current of the fuse link is the maximum current which it will carry continuously without deterioration and undue heating. The rated current of the fuse link shall be as stated in the schedules and each fuse link shall be suitable for the fuse units

I.1.2 FUSE LINK

The fuse links are required to give protection against short circuits. They shall be so rated and shall have such characteristics as to be suitable for selective operations with the fuse links at present in use on the system namely Type K; i.e.,fast (NEMA SG2).

I.2. STANDARDS

IEC	***International Electrotechnical Commission***
IEC 62271-102	*Disconnector and earthing switches for alternating current*
IEC 60694	*Common specification for high-voltage switchgear and control gear standards.*
IEC 60282-2	*High voltage expulsion fuses*
ANSI	***American National Standards Institute***
ANSI C 37-42	*Melting currents for Type K (fast) fuse links*

I.3. TESTING AND INSPECTION

Testing and Inspection shall be carried out according to Specification and the IEC Standards.
The Employer may accept type test certificates on similar plant, issued by a reputable testing facility, within last 5 years of the bid closing date.

I.3.1 FUSE CUT-OUT

All fuse cut-outs offered in this Contract, shall have been fully tested in accordance with the practices and tolerances indicated.

Type test certificates shall be submitted.

The Routine tests shall be carried out in accordance with IEC Standards.

I.3.2 FUSE LINK

All fuse links offered in this Contract, shall have been fully tested in accordance with the practices and tolerances indicated.

Type test certificates shall be submitted.

The Routine tests shall be carried out in accordance with IEC Standards.

I.4. PERFORMANCE CHARACTERISTICS

I.4.1 FUSE CUT-OUT

a) Ratings

Fuse Cut Out units shall comply with the following electrical characteristics:

○ Rated Voltage	24 kV
○ Rated Current	100 A
○ Rated mainly active load current breaking capacity	100 A
○ Rated Impulse Withstand Voltage - dry across isolating distance	125 kV
○ Power Frequency Withstand Voltage across isolating distance	50 kV
○ Asymmetrical Interrupting Current	10 kA

b) Mounting arrangement and fabrication

The Pole-mounted fuse cut-outs shall be supplied complete with galvanized steel brackets, bolts, nuts and washers for mounting on a concrete pole or a galvanized steel cross-arm.

They shall be provided with a latch mechanism which will open the fused element when the fuse has operated. The latch mechanism shall be constructed to be easily operated from the ground with the aid of an operating stick.

Insulators shall be of porcelain, to withstand a mechanical force of 1600 N. Current carrying equipment shall be made of copper or copper alloy.

Terminations shall be suitable for connection of Al or Cu compression terminal lugs.

I.4.2 FUSE LINK

To be compatible with Fuse Cut-Out quoted (to be accommodated appropriately in the fuse holders)

a) Ratings

The fuse link shall have current characteristics, generally in accordance with NEMA SG2 Class K.

○ Continuous Current	1.5 x I rated
○ Maximum Clearing Time at 5 x I rated	3.5 ± 0.5 sec
○ Maximum Clearing Time at 10 x I rated	0.75 ± 0.15 sec
○ Maximum Clearing Time at 30 x I rated	0.1 ± 0.03 sec
○ Maximum Clearing Time at 50 x I rated	0.045 ± 0.01 sec

The Contractor shall provide time-current characteristics of all the distribution fuse links in the offer. The performance characteristics of the fuse links shall include melting time-current characteristics

The Contractor shall state the minimum and maximum melting currents required to melt the fuse links at the three appropriate time points used in Table 6 of ANSI C37.42

b) Mounting arrangement and fabrication

The fuse link shall be capable of accepting IEC/NEMA fuse elements from 10 A up to a maximum continuous current rating of 100 A.

The toggle mechanism shall provide locking action to protect the fuse link from shock. A spring assisted flipper shall assist arc interruption by withdrawal of the fuse tail.

The fuse link cap shall preferably be of the non-expandable type.

The arc shortening rod, if provided, shall be permanently attached to the fuse link cap. Fuse link material shall preferably include fiberglass.

All current carrying parts of the fuse links shall be of non-ferrous material, the main requirement being resistance to atmospheric corrosion. Tin is not acceptable for the fuse link.

A lifting eye shall be provided on the fuse link and designed for use with a portable hook stick.

The fuse isolators will be operated by means of the Employer's standard operating rod and/or load buster tool so that no separate operating mechanism is required.

The fuse isolator shall be provided with hooks for a portable load buster tool. The Contractor shall provide evidence that the hook arrangement which is provided has been approved by the portable load buster tool manufacturer or alternatively shall provide evidence of satisfactory operation by an electrical utility.

II. POLE MOUNTED SWITCH FUSE CUT OUT

II.1. SCOPE

Pole mounted Switch Fuse Cut-out shall be used in the low voltage overhead distribution systems to provide overload protection/reliable isolation especially for LV feeders of distribution transformers. It shall be of fully insulated three poles and neutral type On-load switch Disconnector with High Rupturing Capacity (HRC) fuses for the three phases and a solid link for the neutral.

The type of HRC fuse to be used with the Switch Fuse Cut-out shall be "Size 1 and 2" (NH 1 and NH 2) with knife edge (blade) type contacts.

II.2. STANDARDS

IEC	***International Electrotechnical Commission***
IEC 60947-1 & 3	*Low Voltage Switchgear and Control gear*
IEC 60269	*Low Voltage Fuses*
BS EN 1461 (1999)	*Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles, Specifications and Test Methods*

II.3. TESTING AND INSPECTION

Testing and Inspection shall be carried out according to Specification and the IEC Standards.
The Employer may accept type test certificates on similar plant, issued by a reputable testing facility, within last 5 years of the bid closing date.

II.3.1 SWITCH FUSE CUT-OUT

All Switch Fuse Cut-outs offered in this proposal shall have been fully tested in accordance with the practices and tolerances indicated.

Type test certificates shall be submitted.

The Routine tests shall be carried out in accordance with IEC Standards.

II.3.2 HRC FUSE

All HRC fuses offered in this proposal shall have been fully tested in accordance with the practices and tolerances indicated.

Type test certificates shall be submitted.

The Routine tests shall be carried out in accordance with IEC Standards.

II.4. PERFORMANCE CHARACTERISTICS

II.4.1 SWITCH FUSE CUT-OUT

Switch Fuse Cut-out shall comply with the following electrical characteristics:

○ Rated Operating Voltage	400 V
○ Rated Insulation Voltage	1000V
○ Rated Current	400 A
○ Rated Making Current at 0.65 pf at 400V	750 A
○ Rated Breaking Current at 0.65 pf at 400V	750 A
○ Short Time Current/duration	10 kA/ 0.5 sec.
○ Short-circuit Making Capacity	17 kA
○ Degree of Protection	IP 20
○ Utilization Category	AC-22B
○ Power Frequency Withstand Voltage	3.5 kV
○ Impulse Withstand Voltage	9.8 kV peak

II.4.2 FUSE

The HRC fuse links to be mounted on to the lower housing (i.e. fuse carrier) shall conform to IEC 60269.

○ Rated Voltage	500 V
○ Rated Current	100A, 160A
○ Rated Breaking Capacity at 0.8 power factor	25 kA
○ Maximum Temperature Rise	55℃
○ Maximum Permissible Power Dissipation	
○ For 100A	7.5W
○ For 160A	16W

The continuous ratings of the fuse links to be supplied shall be as stipulated in the Price Schedule 1.

II.5 CONSTRUCTION

II.5.1 GENERAL

The Switch Fuse Cut-outs shall be all insulated and made of non-hydroscopic, weather resistant, robust, glass fibre reinforced Polyamide compound possessing high thermal stability and good mechanical strength to withstand rough usage without any fracture or permanent distortion. It shall be treated to provide protection against distortion due to Ultra-violet radiation. It shall be suitable for use under the usual climatic and weather conditions in Afghanistan.

The Switch Fuse Cut-out shall be of two parts; upper housing and a hinged lower housing.

II.5.2 Upper housing and Fuse base

The upper housing shall be securely fixed to an integral mounting bracket and the lower housing shall be hinged to the upper housing. The upper housing shall be a single unit with four compartments. Three compartments shall be fitted with HRC fuse bases for the three phases and the other compartment fitted with neutral link. It shall have all required terminals for connecting incoming and outgoing cables.

II.5.3 Lower housing

The hinged lower housing shall carry the HRC fuses for the three phases. The construction shall be such that the lower housing (i.e. the HRC fuse carrier) could be attached and detached from the upper housing using an operating stick from the ground level below the unit. The Switch Fuse Cut-out closing (i.e. fuse engaging) and opening (i.e. fuse disengaging) operation shall also be possible to do using the same operating stick from ground level. Neon indicators shall be fitted to the lower housing so that the status (i.e. in operation or not in operation/burnt) of the fuses and the neutral link could be visible from the ground level. The HRC fuses shall be possible to be fitted to the lower housing (i.e. fuse carrier) without using any special tool.

II.5.4 Contacts and Terminals

The conductor terminals and the fuse contacts shall be designed to carry the continuous rated current without exceeding the maximum temperature rise indicated in the relevant standards.

The equipment shall be supplied complete with terminal fittings for terminating 50 – 95 mm^2 Aluminium and Copper cables using cable sockets. The live parts of the contacts shall not be exposed. The cable termination fastener shall have a hexagonal head of 14mm across flat and be accessible for using standard socket spanners. The contact surfaces shall be Tin/Nickel plated to provide effective contact throughout the period of service.

II.5.5 HRC Fuse Link

HRC fuse link shall be of "g" type with Blade Contacts (i.e. Knife edge type). The size shall be either "NH-1" or "NH-2" as specified in the Price Schedule. The contact blade lengths for NH-1 and NH-2 shall be 135±2.5mm and 150±2.5mm respectively. The contact blade thickness shall be 6mm. The fuse shall be provided with a device to indicate whether it has operated or not. The body shall be made of electrical porcelain and filled with a suitable arc quenching material to interrupt the rated short circuit current safely. The contact blades shall be securely fixed to the body.

II.5.6 Mounting Bracket

The Switch Fuse Cut-out mounting bracket shall have the provision for mounting on concrete pole with two numbers of 16mm diameter bolts and nuts and shall be strong enough to withstand the operating forces throughout its service.

The bracket shall be made of hot dip galvanized steel conforming to BS EN 1461 (1999) and shall be treated to prevent formation of white rust.

II.5.7 Operating Stick

The operating stick shall be of fully insulated type, suitable for engaging, removing and replacing the lower housing with the fuse links. The length of the operating stick shall be not less than 2m.

CHAPTER N

Low Voltage Distribution Switchboards

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CHAPTER N: LOW VOLTAGE DISTRIBUTION SWITCHBOARDS

1. SCOPE

This Specification deals with the design, manufacture and testing of low voltage switch boards associated with distribution transformers and feeder pillars and associated equipment, to be installed indoors/outdoors on platforms or poles for taking cables from pole mounted/plinth mounted transformers and indoor transformers.

This Specification defines the main characteristics of this equipment.

Low Voltage Transformer Switch Board

Low voltage transformer switch board type N shall be supplied pre-equipped with:

- Protection:
  - Moulded Case Circuit Breakers (MCCB) on the incoming circuits from transformers;
  - Moulded Case Circuit Breakers (MCCB) on out going circuits;
- Terminals for incoming and outgoing cables;
- Bus bar, insulators, wiring and fixing materials;
- Necessary 3 phase set of CT's and electronic three phase kWh meter as specified in Article 6.3 of this Chapter;
- Enclosure for board; and
- Frame support.

Feeder Pillar

The equipment required for operating Feeder Pillars (please refer to DWG. No. N-06) are:

- Protection:
  - One 3 phase MCCB rated at 250 A (Type1) and 160 A (Type 2) for incoming
  - 6 numbers (Type 1) and 4 numbers (Type 2) of 63 A 3 phase MCCB for the out going circuits;
- Terminals for incoming and outgoing cables;
- Bus bar, insulators, wiring and fixing materials;
- Enclosure for board; and
- Frame support.

The above LV switch boards, the feeder pillars must come with all necessary terminals and the earthing arrangement and all materials required for earthing. The Feeder Pillars will be outdoor weather proof type with protection category IP65.

2. STANDARDS

IEC		*International Electrotechnical Commission*
○ IEC 60439	:	Factory- Built Assemblies of LV Switchgear and Control Gear.
○ IEC 60947.1/2/3	:	Low-Voltage Switchgear and Control Gear
~~○ IEC 60664-1~~	:	~~Low Voltage Systems; principal requirements; tests~~
○ IEC 60269	:	Low voltage fuses.
○ IEC 60898	:	Electrical accessories – Circuit Breakers for over-current protection for households and similar installation

3. TESTING AND INSPECTION

Testing and inspection will be carried out according to the General Technical Specifications of Chapter B.

Each component of the switchboard will be type tested and routine tested according to the relevant IEC Standards. In addition, the complete switchboard will pass the following:

a) Type tests

- Temperature-rise limits;
- Dielectric properties;
- Short-circuit withstand test;
- Effectiveness of protective circuits;
- Clearance and creepage distances;
- Mechanical operations;
- Degree of protection.

b) Routine Tests

- Inspection of the ASSEMBLY including wiring and electrical operation tests;
- Checking of protective measures and of the electrical continuity of the protective circuit;
- Dielectric tests;

4. GENERAL ELECTRICAL DATA

Please refer to the General Technical Specification of Chapter B and Technical data Sheets of Chapter Y.

5. GENERAL DESIGN

The switchboard cabinet enclosures shall consist of an indoor/outdoor weather-proof, non- rusting enclosure made of composite material (polyester glass reinforced) or stainless steel or galvanized steel for rated voltage 0.6/1 kV for floor mounting on a concrete base or wall or pole mounting. The switchboard will mainly consist of the following items:

- Frame support and bus bars
- Necessary fuse board /circuit breakers for incoming/outgoing circuits
- Terminals and wiring
- Mounting hardware
- Earth arrangement and materials

The relevant drawings of Chapter Z are for illustration only, without prejudice to the equipment, according to the size and optimal cabinet design; to be approved by the Project Manager.

Combination and quantity of items will depend on what is the capacity of the transformer the LV switch board is fed from , according to the current in the outgoing and incoming circuits and for easy accommodation in case, in future, the transformer capacity needs upgrading.

The general arrangement and electrical characteristics of the components will be in accordance with the following Table 1:

Table: 1

LV Switchboard Type	Transformer Capacity(KVA)	Incoming MCCB Rating (A)	Outgoing MCCB Number & Rating (A)
N1	630	1000	4X250A,5X160A
N2	400	630	3X250A,3X160A
N3	250	400	4X160A
N4	160	300	3X160A
N5	100,63	200	2X160A
N6	Feeder Pillars 1	250	6x63A
	Feeder Pillars 2	160	4x63A

Note: 1. MCCBs will have adjustable current settings (0.63 to 1).
2. Protection class of the switchboards will be according to their use indoor or outdoor.

6. EQUIPMENT

6.1 Fuse Board

Designed and tested according to IEC 60269 and relevant addenda.

6.1.1 Mechanical design

The board shall be of robust design and be fit for the purpose it will be used. It shall be possible to replace the fuse-links easily and safely. Each switchboard shall be supplied with a fuse puller to extract the fuse in safe conditions.

The fixed connections shall be such that the necessary contact force is maintained under the conditions of service and operation, in particular in the conditions defined by their breaking capacity.

The fuse contacts shall be such that the electromagnetic forces occurring during operation shall not impair the electrical connection between (a) the fuse-base and the fuse-carrier and (b) the fuse-carrier and the fuse-link.

In addition, fuse contacts shall be so constructed and of such material that when the fuse is properly installed and service conditions are normal, adequate contact is maintained (a) after repeated engagement and disengagement and (b) after being left undisturbed in service for a long period.

6.1.2 Insulation Property

The fuses shall be such that they do not loose their insulating properties at the voltages to which they are subjected in normal service.

6.1.3 Temperature Rise

The fuse-holder shall be so designed and proportioned as to carry continuously, under standard conditions of service, the rated current of the fuse-link with which it is provided.

The fuse-link shall be so designed and proportioned as to carry continuously its rated current, under standard conditions of service.

In particular, the temperature-rise limits specified shall not be exceeded when the rated current of the fuse-link is equal to the rated current of the fuse holder.

6.2 Moulded Case Circuit Breaker (MCCB)

6.2.1 General

The MCCBs shall be of the discriminating type, with adjustable ranges for the long delay operation. A standard MCCB base (or frame) will be designed to receive different trip units, calibrated according to the type and capacity of the ratings given above. Thermal overload protection shall be adjustable by the user to values varying between 65 and 100% of the full load rating of the MCCB, and shall have a positive locking system to maintain that setting.

It shall have the following characteristics:

- Designed as a one piece type, be removable and be interchangeable.
- In addition to the "on" and "off" positions, includes an intermediate "tripped" position or trip indicator flag and the mechanism shall be of the trip free type.
- Insulated parts of the units shall be of a reinforced plastic material which has, in addition, a high resistance to solar radiation.
- All current carrying parts shall be of non-ferrous metal, adequate for the rated current capacity.
- Locking facilities shall be provided for locking the MCCB in the open position.
- The Manufacturer shall provide charts of the characteristic curves of the proposed MCCBs.

6.3 Electronic Meter and CT's

The transformer metering is for the purposes of optimizing transformer load management and for loss reduction initiatives.

The CT and meter arrangement for the Transformer LV panels shall be as indicated on drawings H06 and H07. The meters shall be as specified in Chapter O, Articles 3 and 4 except as below. The meter:

- shall be electronic three phase CT operated of at least class 0.5 accuracy;
- shall have provision of RS232 port and optical port for down loading the data;
- should have recording features and at least 8 registers to record data in different time zones;
- shall have sufficient memory to capture the last 45 days load profiles, including (half hour basis maximum demand, no. of interruptions, duration of interruptions, the voltage and load data, etc.);

- should have tamper indications warning of unauthorized tampering with the meter functions; and
- Shall be programmable and the necessary software to program the meters shall be included in the supply.

Full details of the proposed metering arrangement with manufactures data on the proposed meter and software shall be provided.

6.4 CONNECTIONS

a) Upstream fuse board

The main fuse board shall be located at the top of the LV switchboard.

The incoming connections shall be capable of connecting 240 mm^2 copper cables per phase. The outgoing connection of the main fuse board shall be connected to the general bus bar.

The capacity of the main fuse pre-installed on the LV Switchboard shall be in accordance with the capacity of the transformer.

b) Downstream MCCBs

The downstream MCCBs shall be located at the lower part of the LV switchboard.

The incoming connection palm of downstream MCCB shall be connected to the general bus bar.

The outgoing connection palm shall be capable of connecting LV Cu or Al cables of cross sections 50-150 mm^2 per phase. All the bimetal lugs for connection of LV cables shall be provided with the downstream MCCBs.

Adequate space shall be provided to connect incoming/outgoing LV Cu or Al cables to MCCBs

c) Trip unit

Trip unit shall be interchangeable by the user.

- Equipped with thermal and magnetic trips
- It shall include overload protection with adjustable tripping time
- It shall include short circuit protection with adjustable tripping threshold.

7. ENCLOSURE

7.1 GENERAL

The galvanized steel, the enclosure shall be adequately protected against corrosion and a statement on the method of protection proposed shall be included.

The base, the panel and the door shall be constructed with hot dip galvanized steel followed by painting of minimum thickness of 30 microns. Sufficient pre-treatment of the zinc surface shall be carried out as necessary in order to guarantee long life adhesion. The weather-proof ability of the paint used should be proven and documented. The inside and outside of the enclosure shall be painted in gray colour.

7.2 FIXING

The cabinets shall be suitable to be fixed on walls and on poles. The fixing system will be so designed that the supporting load is applied by an adequately reinforced frame or structure, without utilizing the cabinet walls.

The supply of mounting hardware including stainless steel brackets shall be provided by the Contractor for pole mounting (where applicable), including bolts, nuts and specific tools. All mounting openings shall be provided with grommets to prevent penetration of any matter (dust, water) into the cabinet.

7.3 CABLE ENTRANCES

Cables entries shall be located on the bottom of the enclosure. The cable entries shall be equipped with cone grommets or any equivalent system to prevent penetration of any matter into the cabinet.

7.4 PROTECTION AND EARTHING

Design of the cabinet must be vandal and pilferage proof. The strength at all points must be sufficient to withstand the stresses imposed by manually driven tools (such as hammer), equivalent to 20 joules.

The cabinet must be designed to provide natural ventilation to avoid overheating inside when exposed to the sun rays.

The degree of protection must be IP65 for outdoor and IP3X for indoor use according to IEC 60529 for metallic enclosure. Ventilation design and cable entrance shall not reduce the protection degree.

The connection and disconnection of the incoming cable, outgoing cables and electrical plant must be made on live line and design of the cabinet must comply with all safety conditions for workers and international regulations for the live-line working.

The neutral terminal in the cabinet shall be connected to the transformer neutral.

The metallic enclosure will be equipped with an additional internal earthing terminal electrically bound to the cabinet.

The door(s) will be electrically bonded to the cabinet by a flexible copper strap.

CHAPTER O

Part I - Energy Meters
Part II – Meter Boxes

Table of Contents

ELECTRONIC ENERGY METERS

1. Purpose

This specification for supply nominates the minimum requirements of single phase and three phase electronic energy meters. General Technical Particulars are shown in the Technical Data Sheets attached with this specification.

2. Scope of Supply

The scope for supply includes design, manufacture, assembly, inspection, testing at manufacturer's works before dispatch, acceptance, packing and transportation of the single phase and three phase meters including base computer station, etc. to the designated Employer's store in Kabul and Mazar-e-Sharif.

The energy meters shall be of Digital Programmable Type with remote data communications facilities suitable for future connection to communication modems and AMR with the help of GSM network or any other appropriate system.

Each unit of the three phase meter shall be housed in individual secured meter box having additional space for future communication modem accommodation.

The major equipment detailed in the present specification comprises the following:

- Single Phase electronic meters with maximum demand
- Three phase electronic meters with maximum demand and load profile housed in individual meter box.
- Hand Held Units for reading and programming (HHU)
- Base Computer Stations complete with Computers, Windows based Computer Software for programming and processing measurements and readings.
- Portable Meter Testing Sets for testing of the Energy Meters.

The contract is designed as a supply contract on unit price basis and quantities may fluctuate up or down as indicated in the BDS (ITB 41.1) during the pre-contract negotiation for finalization of contract.

3. Standards for Energy Meters

For the purpose of design, manufacture, quality of new material, tests and manufacturing, the equipment shall meet this Specification and the following IEC Standards and recommendations:

IEC 62053 –21	Electricity Metering Equipment (AC) Particular Requirements Part 21 Static Meters for Active Energy (Class 1)
IEC 62056-21	Data Exchange for Meter Reading, Tariff and Load Control Part 21 Direct Local Data Exchange
IEC 60068-2-6	Environmental Testing -Part 2: Tests –Test Fc: Vibration (Sinusoidal)
IEC 61000-4-2	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 2: Electrostatic Discharge Immunity Test - Basic EMC Publication
IEC 61000-4-3	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 3: Radiated, Radio-Frequency, Electro-magnetic Field Immunity Test
IEC 61000-4-4	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 4: Electrical Fast Transient/Burst Immunity Test - Basic EMC Publication
IEC 61358	Acceptance Inspection for Direct Connected AC Static Watt-hour Meters for Active Energy (Class 1)

Meters which comply with the American National Standards Institute (ANSI) Standards shall also be acceptable

ANSI C12.16	Solid-State Electricity Meters
ANSI C12.18	American National Standard for Protocol Specification for ANSI Type 2 Optical Port
ANSI C12.19	IEEE Standard for Utility Industry End Device Data Tables

Material conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above would also be acceptable. In case the Bidders who wish to offer material conforming to the other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. Copy of such standards with authentic English Translations, shall be furnished along with the offer. In case of any differences between provisions of these standards and provisions of this specification, the provisions contained in this specification shall prevail. In determining the acceptability of any other standard the Project Managers' decision shall be final.

4. Climatic & Geographic Conditions

The electronic energy meters shall be entirely suitable for use under the prevailing conditions as follows:

Altitude	1,700 – 2,100 meter	
Dry period	June to November	
Rainy period	December to May	
Annual rainfall	327 mm	
Air temperature	Warmest month	Coldest month
	+25 °C average, +50 °C noon, +18 °C night	-3 °C average, +2 °C noon, -20 °C night
Air humidity	Average summer	Average winter
	35%	75%
Soil thermal resistivity	Average	Maximum
	+1.2 °C m/W	+3 °C m/W
Maximum solar radiation	1,200 W/m^2	
Wind	Maximum wind velocity	Wind & dust conditions
	25 m/s	Sand & dust storms in summer
Keraunic level	23	

5. General Requirements for Meters

The single and three phase electronic energy meters shall not have any form of mechanical adjustments, such as trim-pots, potentiometers for calibration. The meters shall be factory calibrated and no adjustment of calibration shall be possible outside the factory facilities.

The materials and electronic power components used in the meter manufacturing shall be of highest quality and of reputed make to ensure higher reliability, longer life and sustained accuracy.

The insulating materials used in the construction of meters shall be non-hygroscopic, non-aging and of tested quality.

The meters shall be of compact modern design with no moving parts, convenient to transport and immune to shocks and vibrations during transportation and handling.

The meters shall be designed with application specific integrated circuit and manufactured using Surface Mount Technology (SMT).

The meters cover shall have one transparent window at the front for reading of all the displayed values and parameters, name plate details and observation of all the operation indicators.

The meter-base, meter cover, terminal block & terminal block cover shall be made of unbreakable, high grade, fire resistant, non-flammable reinforced polycarbonate.

All parts of the meters likely to develop corrosion during operating life shall be effectively protected with suitable protective coating;

The meters shall conform to the degree protection class IP 53 for protection against ingress of dust, moisture and vermin;

The meter design shall ensure no isolation link between current and voltage circuits;

The meters shall have secured and sealed mounting arrangements for fixing those in the meter boxes;

Each meter shall be indelibly marked with connection diagram showing the phase sequence for which it is intended and shall be attached to the inner side of the extended terminal block cover. In case of any special precaution is required at the time of testing the meter, the same shall be indicated in the connection diagram.

Reliable sealing arrangement shall be provided to make the meter tamper evident and avoid fiddling or tampering by unauthorized persons. Each meter shall be provided with two seals on the meter body, two on meter terminal blocks, one on communication port and one on MD reset button. However, sealing arrangement shall clearly be explained in the bid.

All the meters shall be of high security design and detect most of the commonly used tamper techniques described in the following sections.

6. Functional Characteristics of Meters

The meters shall have operation indication device by blinking, LED visible from the front of the windows.

The meters shall have the following LED indications:

- Meter Calibration
- Phase available indication
- Tamper occurrence indication

The meters shall display all data and information on LED display units/registers;

The meters shall store data in non-volatile memory (NVM) for a period not less than 10 years under un-powered condition. Battery backup will not be considered as NVM condition;

The meter shall offer capability of time of use monitoring for energy.

The meter shall be capable of registering the time-of-day energy and maximum demand.

The meter shall have real time clock (RTC) backed by built in battery for supporting RTC in case of mains power failure.

The batteries shall have guaranteed life of not be less than 10 (ten) years and shelf life not less than 15 (fifteen) years. The replacement of battery shall be simple and easy.

The meters shall be capable of monitoring and recording load profile information for kW demand for every 30 minutes interval for a period of three months.

The meters shall have self diagnostic features to monitor integrity of data memory location at all time.

The meters shall have the indications for unsatisfactory performance and/or malfunctioning of the following features:

- Time and data on meter display
- All display segments on meter display
- Real Time Clock (RTC) status in meter reading prints out at BCS end
- Non-Volatile Memory (NVM) status in meter reading prints out at BCS end.

The meters shall have configurable automatic scrolling of displays to restrict manual intervention for various displays;

The meters shall have test output in the form of LED accessible from the front and capable of being monitored with suitable testing equipment while in operation.

The meter shall not saturate on passage of direct current which can cause the meter either to stop recording or record inaccurately.

The meter shall not get influenced by any external permanent/electromagnet (s).

The measurement by meter shall not get influenced by injection of A.C. voltages /chopped signal / DC signal and harmonics on the outgoing leads of the meter.

The meters shall have a galvanically isolated optical communication port located in front of the meter for data communication with Hand Held Unit (HHU) or other related data collection device (Common Meter Reading Instrument, CMRI), as per IEC 1107 or equivalent standard. For the scope of this specification the term HHU and CMRI are used interchangeably.

The meters shall have a suitable communication port to interface standard dial up modems (not included in this scope of supply) for remote data collection under future automatic meter reading (AMR) program, for both single and three phase meters

The meter shall record correctly even if the neutral is accidently or incidentally disconnected.

Proper sealing arrangement shall be provided on the meter to make the meter tamper resistant and avoid mishandling by unauthorized person.

The common meter reading instrument (CMRI) shall be capable of being loaded with user friendly software for reading /downloading meter data. The base computer software (BCS) shall be Window based and provided for receiving data from CMRI and downloading instruction from BCS to CMRI.

Communication Port

The meters shall have a galvanically isolated optical communication port as per IEC 1107/ANSI/PACT so that it can be easily connected to a hand held common meter reading instrument for local data transfer.

Terminals and Terminal Blocks for Meters

The terminal block shall be of moulded type with non hygroscopic, non ignitable material of good dielectric and mechanical strength. The terminal block, terminal cover and the case shall ensure reasonable safety against spread of fire.

Extended terminal cover shall be provided to restrict access for tampering without breaking seals.

Sufficient clearance shall be allowed between terminals to avoid flash over. The terminals shall be of electro-plated (or tinned) brass having rating 150% of Imax and of replaceable type.

All connection screws and washers should be tinned/nickel plated brass. The terminals shall be properly bound in the insulation. Terminal screws shall be captive type with pressure plates for connecting to cables. Terminal screws shall not bear directly onto connecting cables.

Aluminum crimping pins of suitable size shall be provided by the manufacturer along with the meters for proper incoming and outgoing termination of the cable ends.

The terminal cover extension shall be designed to cover cable and cable glands completely inside the box to avoid mishandling of the cables by unauthorized persons.

Every meter shall be indelibly marked with a connection diagram attached to the inner side of the extended terminal block cover. In case any special precautions need be taken at the time of testing the meter, the same may be indicated along with the circuit diagram.

The terminal block, the terminal cover and the case shall ensure reasonable safety against spread of fire. They shall not be ignited by thermal over load of live parts in contact with them.

7. Training of Employer's Personnel

The contractor shall organize training on Meter technology, installation, testing and commissioning including operation and maintenance of energy meters etc. to 6 Employer's personnel.

The on-site training shall ensure that the Employer's staff can install, maintain, test and operate the meters, familiarize with base computer system, down load the data, etc. The training shall be provided when the Contractor has completed the supply of first lot of meters and associated equipment.

Training shall include installation of BCS, use of HHU and portable test equipments.

Training shall be provided to a group of 12 nos. of the Employer's staff for operation & maintenance of the meters, computer station and associated equipment. The operation training shall include but not be limited to:

AMR Control Centre Training

- Scheduled and manual data acquisition
- Generation of reports
- Data checking and validation
- Event management
- Resetting of meters

Base Computer Station Training

- Equipment and system familiarization
- System troubleshooting
- Hardware maintenance and replacement,
- Database management,
- System expansion,
- Management of interfaces to other systems,
- System restoration,

8. Meter Testing and Test Inspection

The contractor shall carry out all tests required as per this specification at their own cost and inform the Employer/Project Manager with reasonable advance notice for inspection of the tests as mentioned in the relevant sections of the General Conditions of Contract of this Bidding Documents.

The Employer/Project Manager shall carry out the Routine Test Inspections as and when required or may decide otherwise to get the Test Inspection done by a third party at the cost of the contractor.

8.1 Type tests and routine tests

The energy meter tests to be carried out in accordance with the standards specified herein and shall include but not limited to the following:

- AC voltage test
- Insulation resistance test
- Test of limits of errors
- Tests of mechanical inspection
- Tests on dielectric properties
- Tests of immunity to electrostatic discharges
- Fast transient test
- Radio interference measurement
- Test of accuracy requirements
- Test of no load condition
- Test of starting condition
- Test of meter constant
- Repeatability of error test
- Test of power consumption
- Test of electromagnetic compatibility and interference (refer clause 8.2 of this specification)
- Test for demonstration of anti-tamper features (refer clause 9.6 and 10.6 of this specification)

The Type Test shall be performed at a reference voltage of 230/400V at a reference frequency of 50Hz. The calibration of meters shall be done with accuracy standard of meters for class 0.2 or better.

The type tests for all types of meters shall be carried out duly witnessed by Employer/Project Manager for each consignment of meter supply.

8.2 Testing of Meters

Type Test

The energy meter shall be fully type tested from any of the accredited international testing laboratory as per relevant International Standard. All type tests as per standard and for the parameters which are stringent in the technical specification and tests to demonstrate anti-tamper features should have been conducted before submission of the bid. These type test reports along with forwarding letter of the test house shall form part of the bid without which the bid will be considered incomplete and rejected. The submission of incomplete type test reports shall also call for rejection of the bid.

The type test reports shall not be more than three years old.

Acceptance/Sample test

The acceptance/sample tests will be done as per IEC 61036 & IEC 61358 and shall be witnessed by the representative of the Employer.

Routine Test

Routine tests as per IEC 61036, IEC 60211 and IEC 61358 shall be carried out on all meters and each consignment of meters shall be accompanied by one set of routine test results recorded in tabular form. If the test results are recorded in separate sheets all such sheets pertaining to each consignment shall be bound together as one volume for the approval of the Employer.

Electromagnetic compatibility and Interference

Meters shall meet the following electromagnetic compatibility and interference requirements to avoid use of any unauthorized external magnet for tampering the meter operation:

- The continuous (DC) "stray" magnetic induction shall be 67mT +/- 5% at a distance of 5 mm from the surface of the pole of the electromagnet energized with DC supply;
- The continuous (DC) "abnormal" magnetic induction shall be 0.27 Tesla +/- 5% at a distance of 5 mm from the surface of the pole of the electromagnet energized with DC supply;
- The alternating (AC) "stray" magnetic induction shall be 0.5 mT +/- 5% by placing the meter at various orientations energized by AC supply;

- The alternating (AC) "abnormal" magnetic induction shall be 10 mT +/- 5% by placing the meter at various orientations energized by AC supply;

8.3 Supplier's Quality Assurance Procedures

The Manufacturer / Supplier shall have established a quality assurance system based on ISO 9001 or 9002. The Supplier shall include a documentation of the system with a list of current procedures, an organization chart of the quality organization and the name of the quality manager. He shall also submit a list of quality revisions performed the last twelve months with a list of closed and unclosed findings as well planned revisions the coming twelve months.

The Supplier shall submit for approval a program of quality control and inspection procedures to assure that the product during manufacture and on completion complies with the specified requirements.

9. Single Phase Electronic Energy Meters

9.1 Basic characteristics

The basic characteristics of the single phase meters shall include but not be limited to the following:

- Electronic meters shall be of one element for single phase installation
- Nominal voltage and service type shall be 230V and operating range shall be -30% to +20% of rated voltage. Auto-programmable in range of 120-300 VAC to be available.
- Supply frequency: 50 Hz ± 5 % and PF zero to 1 (lead and lag)
- Power supply: bottom connected
- Rated current: base current (Ib) 10 A and maximum current 60 A.
- The meter shall start registering energy at 0.2% of base current at unity power factor
- The maximum continuous current in the meters shall be the one the meter purports to meet the accuracy requirement of the specification.
- Accuracy class 1 (Standard IEC 62053-21) or better.
- The active and apparent power consumption in each voltage circuit including the power supply of meter at reference voltage, temperature and frequency shall not exceed one (1) watt.
- The apparent power taken by each current circuit at basic current (Ib), reference frequency and temperature shall not exceed 2 VA
- Connection shall be direct.

9.2 Requirements for measurement

Meters shall measure the energy consumption by means of digital sampling or any other recognized method,

Digital algorithm for measurements processing shall take into account the presence of harmonics

9.3 Reading of meters

In case of interruption of electricity supply, the electronic meter register shall retain all metered values in a memory.

Reading shall be performed through:

- Direct reading from display as basic method
- Alternatively by optical port protocol.

9.4 Display

All information including cumulative active energy (kWh) at all loads & power factors and maximum demand (kW) of each demand interval of 30 minutes registered by the meters shall be shown alphanumerically on a LCD for display.

The maximum demand shall automatically reset at 2400 hrs. on the last day of each calendar month for which a minimum 30 years of calendar shall be programmed by the manufacturer.

The active forwarded energy (kWh) and maximum demand (kW) shall be registered and stored for a minimum period of six months for billing purpose.

The register shall record and display starting from zero for a minimum period of 1500 hours, the energy corresponding to rated maximum current at reference voltage and unity power factor.

The minimum number of digits on the display shall be 6, with 5 integers and 1 decimal. The height of the digit shall be minimum 9.0 mm. This shall be programmed only in the factory and there shall not have any provision for programming at any other place.

In addition to providing the serial number of the meter on the display plate, the meter serial number shall also be programmed into meter memory for identification through the communication port for CMRI/meter reading print out.

9.5 Display Parameters

The meters shall display the billing parameters in Auto Display mode only in following sequence:.

- LED test display
- Real Time
- Date
- Cumulative active energy (kWh)
- Latest six months maximum demand (kW)
- Instantaneous phase voltage, current
- Cumulative tamper occurrence count

9.6 Anti-Tamper Features

The meter shall be immune to registration for reversal of current direction.
The meter shall have the following Anti-Tamper Features and record forward energy under the following conditions:

- Interchanging of incoming and outgoing wires at meter terminals.
- Interchanging of phase and neutral terminals
- Incoming neutral disconnected and outgoing neutral & load connected to earth
- Outgoing neutral connected to earth via resister and load connected solidly to ground
- Phase and neutral interchanged at incoming and load connected to earth

The bidder shall furnish the detail explanations as to how the meter is able to detect / protect recording the above tamper and fraud features with sketches and phasor diagrams if required. Additional features, if any, in the meter may also be clearly indicated.

9.7 Nameplate

The meters shall have printed, in English, in indelible manner the following minimum information:

- Manufacturer's name or trademark
- Meter serial number. If serial number is marked on a plate fixed to the cover, the number shall also be marked on meter base.
- Meter type
- Meter class
- Nominal voltage operating range
- Base current and maximum current
- Frequency
- Accuracy class
- Watt-hour constant
- Year of manufacture
- Identification of system service (number of wires and connection)
- Employer's name: Ministry of Energy Water

9.8 Meter cover

The meter case and cover and the extended terminal block shall be of fire resistant poly phenyl oxide or reinforced polycarbonate.

The meter cover shall be properly sealed with appropriate sealing materials (details to be specified in the bid) with adequate number of sealing tools (details to be specified in the bid).

9.9 Protection class

The meters shall be able to operate outdoor. Minimum protection class shall be IP53 according to IEC 60529.

9.10 Guaranteed Characteristics

The bidder shall indicate a list of guaranteed characteristics of his equipment in the Schedules of Technical Data Sheets, Table 1.

9.11 Typical curves

The offer shall show typical curves with its variation ranges, which the Bidder shall guarantee for all meters. Alternatively variation ranges could be shown in the form of tables. Error limits and deviations from these limits are to comply with relevant Standards.

9.12 Other capabilities

The meters shall comply with the above technical specifications but other additional features are welcomed for future upgrading or retrofit. Description of the possible additional characteristics such as Time of Use Metering, Modem, etc. shall be included in the offer. The bid evaluation shall be based only on the basic requirements requested in this Specification.

10. Three Phase Electronic Energy Meters

10.1 Basic characteristics

The basic characteristics of the three phase meters shall include but not be limited to the following:

- Electronic meters shall be of three element for three phase installation 3x230/400V (3 phase, 4 wire)
- Nominal voltage and service type shall be 230 V and operating range shall be –30% to +20% of rated voltage. Auto programmable on range of 200-500 VAC shall also be acceptable.
- Supply frequency: 50 Hz ± 5 % and PF zero to 1 (lead and lag)
- Power supply: bottom connected
- Rated current: base current (Ib) 10 A and maximum current 60 A.
- The meter shall start registering energy at 0.2% of base current at unity power factor
- The maximum continuous current in the meters shall be the one the meter purports to meet the accuracy requirement of the specification.
- Accuracy class; 1 (Standard IEC 62053-21) or better.
- The active and apparent power consumption in each voltage circuit including the power supply of meter at reference voltage, temperature and frequency shall not exceed one (1) watt.
- The apparent power taken by each current circuit at basic current (Ib), reference frequency and temperature shall not exceed 2 VA
- Time of day maximum demand (register for 1 year)
- Connection shall be direct
- Load profile (register for minimum three months)

10.2 Requirements for measurement

Meters shall measure, by means of digital sampling (or any other recognized method) of the energy consumption

Digital algorithm for measurements processing shall take into account the presence of harmonics

10.3 Reading of meters

In case of interruption of electricity supply, the electronic meter register shall retain all metered values in a nonvolatile memory

Reading shall be performed through:

- Direct reading from display as basic method
- Alternatively by optical port protocol

The meter shall function accurately irrespective of phase sequence of the main supply.

The meter shall be functional when power supply from either any two phases or any one phase and neutral is available to the meters.

The meter shall continue functioning even if the neutral of the potential supply is disconnected.

10.4 Display

All information including cumulative active energy (kWh) at all loads & power factors and maximum demand (kW) of each demand interval of 30 minutes registered by the meters shall be shown alphanumerically on a liquid crystal display (LCD).

The maximum demand shall automatically reset at 2400 hrs. on the last day of each calendar month for which a minimum 30 years of calendar shall be programmed by the manufacturer.

The active forwarded energy (kWh) and maximum demand (kW) shall be registered and stored for a minimum period of six months for billing purpose.

The register shall record and display starting from zero for a minimum period of 1500 hours, the energy corresponding to rated maximum current at reference voltage and unity power factor.

The list of display shall be configurable and the selection of display shall be via the buttons on the front panel

Automatic scrolling of displays shall also be configurable so that no manual intervention is required to access various displays.

The minimum number of digits on the display shall be 7 with 6 integers and 1 decimal. This shall be programmed in the factory and the meter shall not be programmable at site.

10.5 Display Parameters

The meters shall display the following parameters on automatic scrolling or manual display mode.

- LED test display
- Tariff name
- Real time
- Date
- MD reset count
- Instantaneous power factor
- Phases present
- kWh import energy register
- Current active rate register
- kW maximum demand register
- Maximum demand time
- Maximum demand date
- Billing maximum demand
- Milling maximum demand time
- Billing maximum demand date
- Rising demand register
- Tariff rate register
- Tariff billing register
- Number of meter reads

10.6 Anti-tamper features

The meters shall be capable of recording following commonly occurring tampers with date and time:

- Missing voltage with phase identification
- Missing current with phase identification
- Current polarity reversal with phase identification
- Neutral disturbance
- Magnetic influence
- Current imbalance

- Current shorting

10.7 Nameplate

Meters shall have printed, in English, in indelible manner the following minimum information:

- Manufacturer's name or trademark
- Meter serial number. If serial number is marked on a plate fixed to cover, the number shall also be marked on meter base.
- Meter type
- Meter class
- Principal units of measurement
- Nominal voltage operating range
- Base current and maximum current.
- Frequency
- Accuracy class
- Watt-hour constant
- Year of manufacturing
- Identification of system service (number of wires and connection)
- Owner's name: MEW/DABS

10.8 Meter cover

The meter case and cover and the extended terminal block shall be of fire resistant poly phenyl oxide or reinforced polycarbonate.

The meter cover shall be properly sealed with appropriate sealing materials (details to be specified in the bid) with adequate number of sealing tools (details to be specified in the bid).

10.9 Protection class

The meters shall be able to operate outdoor. Minimum protection class shall be IP53 according to IEC 60529.

10.10 Guaranteed Characteristics

The Bidder shall indicate a list of guaranteed characteristics of his equipment in the Schedules of Technical Data Sheets, Table 2.

10.11 Typical curves

The Bidder shall show the typical curves with its variation ranges, which the Bidder shall guarantee for all meters. Alternatively variation ranges could be shown in form of tables. For error limits and deviations from these limits it should be referred to corresponding standards.

10.12 Other capabilities

The meter shall comply with the above technical Specification but other additional features should be welcomed for future upgrading or retrofit. Description of the possible characteristics such as Time of Use Metering, Modem, etc. shall be included in the offer. The bid evaluation shall be based only on the basic requirements ask for in this Specification.

10.13 Meter Boxes

10.13.1 Scope Supply

The three phase meters shall be housed in individual meter boxes complete with transparent front cover and adequate sealing arrangement to prevent all possible types of tampering, etc. The meter box viewing window shall be coated with non-scratchable silicon material. A suitable handle or knob shall be provided for opening the box door.

10.13.2 Standards

The meter boxes shall at least comply with the following standards:

IEC 600068	Environmental Testing General and Guidance
IEC 60529	Degree of Protection Provided by Enclosures (IP-Code)
IEC 60947-2	LV Switch Gear and Control Gear

10.13.3 Testing and Inspection

Materials and equipment tests will be inspected at the manufacturer's works.

10.13.4 Type Tests

The meter box shall be tested by an independent testing laboratory in accordance with the appropriate standards. These tests reports shall be submitted for acceptance and approval by the Employer prior to carry out of the routine tests. The tests shall include but not be limited to the following:

- insulation level,
- shock/impact withstand,
- water protection and ageing,
- stability at high temperature, temperature withstanding in boiling water for 5 minutes.

10.13.5 Routine Tests

Full tests to prove all characteristics described in this Specification.

10.13.5 Enclosure

The meter boxes enclosure shall consist of an outdoor weather-proof, flame retardant, non-rusting enclosure made of poly phenylene oxide for rated voltage 0.6/1 kV for wall mounting or pole mounting type.

The wall thickness of the enclosure shall be minimum of 3 mm at the back side and 2.5 mm on other sides and have temperature withstanding capacity of boiling water for minimum 5 minutes without distortion or softening.

Adequate clearance shall be provided on all sides of the meters from the walls of the enclosure when the meters are fixed inside the boxes.

The front cover of the meter box shall have scratch and break resistant transparent silicon window to see through meter readings of all relevant data displayed on the meter window. The window shall be ultrasonically welded to resist ingress of moisture through the window into the box.
Access to the optical port to read through HHU/CMRI shall be provided without opening the box. If a separate cover is provided, it shall have provision for served pad lock management. It shall not be possible to access TTB through this window.

The base of the enclosure shall have knockouts for cable entries. The degree of protection of the board shall be IP 54.

Metallic lable with letters "DABS" and P. O. No. & date shall be engraved on the top half while the Manufacturers name at the bottom half of the cover. A blank sticker shall also be fixed to the meter box for use of the field staff to indicate Service no., etc.Secured door shall be provided to access the meter data with CMRI and the door shall have tamper proof seal to prevent unauthorized access to the meter. The tamper proof sealing shall be of appropriate sealing materials (details to be specified in the bid) with adequate number of sealing tools (details to be specified in the bid.

The cover shall be able to withstand a shock of 6 joules (equivalent to 1.5 kg hammer falling from 0.4 m) without any damage.

The supply of mounting hardware including brackets, etc shall be provided by the Contractor for wall / pole mounting including, bolts, nuts, specific tools. All penetrations for mounting shall be provided with grommets to prevent penetration of any foreign body into the enclosure. Cables entries shall be located at the bottom of the enclosure.

Design of the enclosure shall be vandal proof and anti-pilferage. The enclosure shall be designed to provide natural ventilation to avoid overheating inside when exposed to the sun rays.

11. EXCEPTIONS

The Bidder shall attach a list of exceptions which indicate with clear explanations the deviations of his offer regarding these Specifications. Not presenting a list of exceptions shall imply that the Bidder is in complete accordance with the requirements of the present Specification.

12. INSTRUCTION MANUALS

Together with the supply of meters, five (5) complete copies of the following instruction manuals shall be included for each type of meter:

- Mounting, connection and operation manuals, including parts manual;
- Installation and use of software.

Manuals shall be in English and Dari. Instructions shall be clear and precise with no ambiguities. If necessary, instructions should be accompanied by sketches, diagrams.

The Employer may ask for additional instructions or information if the manuals seem to be insufficient or unsatisfactory. The Contractor is obliged to provide all information required by the Employer.

13. TECHNICAL ASSISTANCE

The Bidder shall include in his offer technical assistance for installation and operation of meters, for programming and software use and for training required for correct use of the equipment.

14. SPARE PARTS

The Bidder shall include in his offer a list of spare parts which he considers necessary or convenient to cover five (5) years of operation. Spare parts shall be identical, in all aspects, with the equipment supplied. All spare parts shall be supplied with respective reference codes to facilitate future procurement.

15. GUARANTEE

The Bidder shall state clearly in his offer the guarantee period for each piece of equipment. The minimum acceptable guarantee period shall be two (2) years from the date of handing over the equipment or system.

16. ACCESORIES AND SPECIAL TOOLS

The Bidder shall indicate and supply all accessories and special tools which are required for mounting, adjusting, maintaining and operating the offered equipment as well as the necessary test tools, together with a list of unit prices.

17. TESTS

The Bidder and Contractor for the equipment shall submit all protocols and test results (type tests with the offer and routine tests with delivery of supplies) performed on equipment according to the specified international standards.

18. REFERENCE LIST

The Bidder shall include in his offer a list of its principal clients, with contact details, to whom the manufacturer has supplied equal or similar meters as indicated in the present Technical Specification.

19. PACKING

All packing shall assure safe transport of the equipment under all conditions and limitations that could be encountered. The packing shall protect the equipment up to arrival at its final destination against breakage, damage and losses due to breakage of the covering. The final packing shall provide easy handling, transport and warehousing. Each package shall indicate the number of parts it contains, type, name of manufacturer, the purchase order/contract number, shipment number, box number, the net and gross weight and the permissible stacking height, country of origin and the owner's code mark.

CHAPTER O

Part II - Meter Boxes

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1. METER BOXES

1.1 SCOPE

The meter boxes as illustrated in Chapter Z, drawing O-01 are used to incorporate up to nine (9) single and/or three phase meters with mini-circuit breakers (MCB) and terminal blocks for the connection of the outgoing service cables.

The mini-circuit breakers and terminals shall be attached to standard rails.

The meter boxes enclosure shall consist of an outdoor weather-proof, non-rusting enclosure made of composite material (polyester glass reinforced) or stainless or galvanized steel for rated voltage 0.6/1 kV for floor mounting on a concrete base, wall mounting or pole mounting

The doors of the meter box shall be provided with a locking device.

The Meter Box consists of the following main parts:

- Enclosure
- Terminal block assemblies
- Miniature Circuit Breakers (MCB)
- Mounting hardware for types O-1-1 to O-1-4

1.2 STANDARDS

The meter boxes shall basically comply with the following standards:

IEC 600068	Environmental Testing General and Guidance
IEC 60529	Degree of Protection Provided by Enclosures (IP-Code)
IEC 60947-2	LV Switch Gear and Control Gear

1.3 Testing and Inspection

Materials and equipment will be inspected at the manufacturer's works.

1.3.1 Type Tests

The meter box shall be tested by an independent testing laboratory. These tests shall be submitted with the bid. The tests will include insulation level, shock withstand, water protection and ageing.

1.3.2 Routine Tests

Full tests to prove all characteristics described in this Specification.

1.4 ENCLOSURE

The meter boxes enclosure shall consist of an outdoor weather-proof, non-rusting enclosure made of composite material (polyester glass reinforced) or stainless or galvanized steel for rated voltage 0.6/1 kV for floor mounting on a concrete base, wall mounting or pole mounting

Following types of enclosures shall be supplied:

Type O-1-1
To incorporate 8 single and/or three phase meters, miniature circuit breakers, and terminal boxes for the connection of 9 underground service cables as illustrated in Drawing O-1-1

Type O-1-2
To incorporate 6 single and/or three phase meters, miniature circuit breakers, and terminal boxes for the connection of 6 overhead service cables as illustrated in Drawing O-1-2

Type O-1-3
To incorporate 4 single phase meters, miniature circuit breakers, and terminal boxes for the connection of 4 overhead service cables as illustrated in Drawing O-1-3

Each enclosure shall be supplied with a set of mounting hardware.

The enclosure shall contain a gear plate and a terminal block of suitable size for the mounting of one incoming and required outgoing service cables.

The base of the enclosure shall have knockouts for cable entries. The degree of protection of the board shall be IP 54.

Doors are to be fitted with padlock holders to prevent unauthorized entry.

The cover shall be able to withstand a shock of 6 joules (equivalent to 1.5 kg hammer falling from 0.4 m) without any damage.

All equipment will be surface mounted on the interior panel and all terminals will be accessible from the front and protected by covers.

In case of galvanized steel, the enclosure shall be adequately protected against corrosion and the bid shall include a statement on the method of protection proposed. The base, the panel and the door shall be constructed with hot dip galvanized steel followed by painting of minimum thickness of 30 microns. Sufficient pre-treatment of the zinc surface should be carried out as necessary in order to guarantee long life adhesion. The weather-proof ability of the paint used should be proven and documented.

The supply of mounting hardware including stainless steel brackets shall be provided by the Contractor for wall, pole and/or ground mounting including, bolts, nuts, specific tools. All penetrations for mounting shall be provided with grommets to prevent penetration of any foreign body into the enclosure if mounting facilities applicable to a particular installation are not used. Cables entries shall be located on the bottom of the enclosure.

Design of the cabinet must be vandal proof and anti-pilferage. The cabinet must be designed to provide natural ventilation to avoid overheating inside when exposed to the sun rays.

1.5 Terminal Block Assemblies

The assembly shall be suitable for the cables indicated in Article 1.4 above.

2. MINIATURE CIRCUIT BREAKERS (MCB)

Miniature circuit-breakers shall be supplied to provide over current & short circuit protection for outgoing service cables.

2.1 STANDARDS

IEC 60947-2	Low Voltage Switchgear and Control Gear– Circuit Breakers.

2.2 Testing and Inspections

Testing and inspection will be carried out according to the Specification and the relevant Standards. Materials and equipment will be inspected in the manufacturer's works.

2.2.1 Type Tests

All type test items should be carried out in accordance with IEC 60947-2.

These type tests shall be submitted with the bid.

2.2.2 Routine Tests

Routine tests shall be completed according the IEC 60068-2

2.3 Characteristics

The MCB's supplied shall have the following characteristics:

a) The MCBs shall be of the one piece type, be removable and interchangeable. The operating mechanism of the MCB shall be mechanically trip free.

b) The MCBs shall be modular type (compact molded case-type)

c) Insulated parts of the units shall be of a suitable reinforced plastic material with a high resistance to solar radiation.

d) Any current carrying parts shall be of non-ferrous metal adequate for the rated current capacity. Padlocking facilities shall be provided to accommodate the circuit breaker in an open position.

e) The MCB shall have a thermal and magnetic tripping unit.

f) The MCBs shall be mounted on DIN rail in the enclosure.

g) The MCBs shall be pre-equipped with terminals for cable connection.

The Bidder shall provide all the characteristics, curves, dimensions of the MCBs offered.

3. EXCEPTIONS

The Bidder shall attach a list of exceptions which indicate with clear explanations the deviations of his offer regarding these Specifications. Not presenting a list of exceptions shall imply that the Bidder is in complete accordance with the requirements of the present Specification.

4. SPARE PARTS

The Bidder shall include in his offer a list of spare parts in Schedule No. 6 of Section VI, which he considers necessary or convenient to cover three (3) years of operation. Spare parts shall be identical, in all aspects, with the parts supplied. All spare parts shall be supplied with respective reference codes to facilitate future procurement.

5. GUARANTEE

The Bidder shall state clearly in his offer the guarantee period for each piece of equipment. The minimum acceptable guarantee period shall be two (2) years from the date of handing over the equipment or system.

6. TESTS

The Bidder and Contractor for the equipment shall submit all protocols and test results (type tests with the offer and routine tests with delivery of supplies) performed on equipment according to international standards.

7. PACKING

All packing shall assure safe transport of the equipment under all conditions and limitations that could be encountered. The packing shall protect the equipment up to arrival at its final destination against breakage, damage and losses due to breakage of the covering. The final packing shall provide easy handling, transport and warehousing. Each package shall indicate the number of parts it contains, type, name of manufacturer, the purchase order/contract number, shipment number, box number, the net and gross weight and the permissible stacking height, country of origin and the owner's code mark.

Table of Contents

1. SCOPE

This Specification covers the general requirements of the design, manufacture, testing, supply and delivery of surge arrestors of gapless metal-oxide type for the over-voltage protection of all new medium voltage equipment such as transformers, switches, underground cables, reclosers, capacitors, that are insulated for a maximum operating voltage of 24 kV in the distribution systems of the nominated urban centres. The required standard ratings are given in the technical data sheets of Chapter Y, Tables P.

2. APPLICABLE STANDARDS

The equipment and components supplied shall be in accordance with the latest editions of the Standards specified below and amendments thereof.

IEC 60099-4 (1999) Part. 4	Surge Arrestors – Metal oxide surge Arrestors without gaps for AC systems
IEC 60099-5 (2000) Part. 5	Surge Arrestors – Selection and application recommendations
IEC 61109 (1992)	Composite insulators for AC overhead lines with a nominal voltage greater than 1000V – definitions, test methods and acceptance criteria

3. TEST AND INSPECTION

3.1 TYPE TEST CERTIFICATES

For type test certificates refer to article 2.8.2 of Chapter B.

The following type tests conforming to IEC 99-4, IEC60507 (1991) and IEC 61109 shall be performed.

a) Insulation withstand test,

b) Residual voltage tests,

c) Long duration current impulse withstand test,

d) Operation duty test,

e) Tests of arrestor disconnectors,

f) Partial discharge test,

g) Seal leakage test,

h) Short-circuit test ,

i) Test of the bending moment,

j) Environmental tests,

k) Radio interference voltage (VIR) test.

The type test certificates shall clearly identity the equipment concerned showing the manufacturer's identity. Type test reports shall include complete drawings and the model/type of the offered arrestor.

Type test reports shall be from a recognized independent testing authority acceptable to the Employer.

3.2 Routine Test

The following routine tests shall be carried out on all the arrestors as per IEC 60099-4 and the test report shall be made available to the Employer.

a) Power frequency reference voltage test.

b) Residual voltage tests.

c) Partial discharge tests.

d) Leakage test

3.3 Inspection

The selected Bidder shall make necessary arrangements for the Employer to inspect the equipment and witness the Acceptance/Sample tests as per Clause 13.2, conforming to IEC 60099-4. Routine test report as per Clause 9.2 shall be provided.

4. BASIC FEACTURES

4.1 Design

The surge arrestors shall be designed for outdoor service conditions stipulated in the general technical specifications of Chapter B. The arrestors shall be supplied complete with the following:

a) Clamps suitable to receive Copper/Aluminum (Line) Conductors from 10 mm – 20 mm corresponding to ACSR conductors of 70/12 up to 185/30 mm2.

b) Earth connection lead or earthing clamp terminals suitable to receive 50mm2 copper conductor.

c) The mounting clamps suitable for bracket mounting on a structure made out of 70 x 70 x 7 mm angle steel.

4.2 Manufacture

The surge arrestor shall be of the non-linear metal-oxide resister type without spark gaps and the non-linear metal-oxide resistor shall be housed in a hermetically sealed insulator casing to prevent ingress of moisture.

4.3 Insulator Details

The housing insulator of the surge arrestor shall be of polymeric type and the insulator sheds shall be designed to minimize trapping of contamination.

The complete arrestor shall withstand a 1000h salt fog test at continuous voltage as described in IEC 60119 / IEC 60507. Additional cycle tests described in IEC 601109 shall also be passed satisfactorily.

4.4 Moisture Sealing

Manufacturing procedure shall include an effective leak test and the manufacturers shall carry out the Special Thermal Stability Test as specified in IEC 60099-4.

4.5 Partial Discharge

Each surge arrestor shall be tested to prove absence of partial discharge contact noise as specified in IEC 60099-4.

4.6 Arrestor Disconnectors

The surge arrestor shall have a device for disconnecting it from the system in the event of arrestor failure to prevent a persistent fault in the system and it shall give a visible indication when the arrestor has failed. The arrestor disconnectors shall be tested as per IEC 60099-4.

4.7 Operation Counter (only when stipulated in Schedule of Prices)

The operation counter shall be of the outdoor type with mounting facility and designed to sense the surge current during the operation of the surge arrestor and to record the number of discharges on a five digit cyclometer type register. It shall also be provided with a milliamp meter to monitor leakage current of the arrestor.

A defective operation counter shall not create any discontinuity in the surge arrestor earthing circuit. The operation counter shall be supplied with the necessary insulating bases to insulate the operation counter as well as the earthing lead. The enclosure of the operation counter shall be made of stainless steel or hot dip galvanized steel.

The quantity of operating counters if required to be supplied shall be as stipulated in the Schedule of Prices.

4.8 INSULATING BRACKET

A robust insulating bracket suitable for mounting the surge arrestor on 70 x 70 x 7 mm angle steel cross-arms shall be supplied with the surge arrestor. The power frequency withstand voltage of the insulating bracket shall not be less than 20 kV.

5. QUALITY ASSURANCE

The manufacture shall possess ISO 9001 quality assurance certification for the manufacture of surge arrestors for the plant, where the manufacture of the surge Arrestors is done. The bidder shall provide a copy of the ISO certificate certified as a true copy of the original by the manufacturer, with the offer.

6. ADDITIONAL REQUIREMENTS

Rating Plate Marking

The following rating and data of the arrestors shall be provided and it shall be weather and corrosion proof. The plate shall be positioned at the bottom flange base and visible from the ground level.

a) Number and year of the Standard adopted

b) Rated voltage / frequency

c) Arrestor type and discharge class

d) Nominal discharge current

e) Manufacturer's identification (name or trade mark)

f) Year of manufacture

g) Serial number

7. INFORMATION TO BE SUPPLIED WITH THE OFFER

The following shall be supplied with the offer

a) Catalogues/Technical literature describing the construction features, materials used for components, operational features of the equipment, indicating the model number.

b) Energy withstand capability and a description of the test carried out to measure the same.

c) Power frequency withstand voltage versus time characteristics curve covering the time range from 0.1 sec to 24 minutes.

d) Dimensional drawings of the bracket mounting base, live conductor clamps, earth lead and automatic earth disconnecting device and overall dimensional drawing.

e) Drawing of name plate to scale incorporating the particulars called for.

f) Completed schedule of technical data sheets of Chapter Y, Tables P.

g) A copy of the Manufacturer's ISO 9001 certificate conforming to Clause 5 – Quality Assurance.

CHAPTER Q

Medium & Low Voltage Insulators and Accessories

TABLE OF CONTENTS

1. SCOPE

This Specification covers the design, manufacturing, testing, supply, delivery and performance requirements of 20kV and 0.4kV pin and string insulators and accessories to be used on the MV/LV distribution systems of the specified urban centres.

2. STANDARDS

The equipment shall comply with the latest editions of the amendments to the Standards/Specifications listed below:

IEC	***International Electrotechnical Commission***
IEC 60120	*Dimensions of Ball and Socket Couplings of String Insulator Units*
IEC 60168	*Tests on Indoor and Outdoor Post Insulators*
IEC 60273	*Characteristics of Indoor and Outdoor Post Insulators >1000 V*
IEC 60305	*Characteristics of String Insulator Units of the Cap and Pin Type*
IEC 60372	*Locking Devices for Ball and Socket Couplings of String Insulator Units Dimensions and Tests*
IEC 60383	*Insulators for Overhead Lines with a Nominal Voltage above 1000 V*
IEC 60471	*Dimensions of Clevis and Tongue Couplings of String Insulator Units*
IEC 60575	*Thermal Mechanical Performance Test and Mechanical Performance Tests on String Insulator Units*
IEC 60720	*Characteristics of Line Post Insulators*

3. TESTING AND INSPECTION

The inspection and tests listed hereinafter shall be carried out in accordance with the provisions of the relevant IEC Standards supplemented by the specific requirements indicated below.
The insulators and accessories shall be subjected to tests as specified below.

3.1 TYPE TESTS

Insulators manufactured or assembled outside the country of the Employer as stated in the type test certificate may be considered as having passed the tests.

The Employer reserves the right to select the insulators at random from the stock and request the manufacturer at his cost to carry out the type tests at a proven independent laboratory to the requisite standards. The following Type Tests are to be performed:

1. Dry lighting impulse withstand voltage test,
2. Dry switching impulse withstand voltage test,
3. Wet switching impulse withstand voltage test,
4. Dry power frequency withstand voltage test,
5. Wet power frequency withstand voltage test,
6. Mechanical failing load test.

3.2 ROUTINE TESTS

These tests shall be carried out on each insulator to be supplied, at the manufacturer's factory to ensure that the product is in accordance with the insulator on which the type test has been carried out.

The manufacturer shall, if requested, supply a certificate giving the result of all the tests carried out on the insulator.

All porcelain insulators shall be subjected to routine flash-over tests.
The following Routine tests are to be performed:

1. Routine thermal shock test,
2. Routine visual inspection,
3. Routine mechanical tests: bending or tensile test

3.3 ACCEPTANCE TESTS

These tests shall be applied on insulators to be supplied, selected at random from the lot by the Employer.

The sizes of samples shall be as recommended in the relevant Standard.

Batches of more than 10 000 insulators shall be divided into an optimum number of equal lots comprising between 2 000 and 10 000 insulators. The results of the tests shall be evaluated separately for each lot.

The acceptance test procedure for any delivery of insulators shall comply with the relevant Standard.

4. PIN INSULATORS

This Specification covers porcelain type pin insulators for use on supporting structures with poles for MV overhead distribution systems.

4.1 Design and Construction

The insulator material shall be made of glazed porcelain.

All insulator units offered shall comply with the characteristics and performance requirements set down in Tables Q of Chapter Y – Technical Data Sheets.
The insulator shall be suitable for various conductor sizes up to 185 mm² (ACSR) conductors.

The relevant vertical dimensions of the insulator shall be such that when combined with the pin insulator spindle the design requirement for conductor clearance from the cross-arm at 20 kV shall be met.

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Precautions shall be taken to prevent chemical reaction between cement and metal fittings by the choice of suitable materials or by the method of construction. Single piece insulator construction is preferred.

The insulating material shall not engage directly with hard metal. Pin insulators shall be provided with a thimble of suitable material. Cement used in the construction of the insulator shall not cause fracture by expansion or loosening by contraction and proper care shall be taken to locate the individual parts correctly during cementing. The insulators may be with or without a center tap groove.

4.2 Accessories

Each insulator shall be supplied complete with a hot dip galvanized forged steel straight pin, with nut, lock nut and flexible washer.

The pins shall be two types, suitable for concrete poles and for steel cross-arms (angle) and fittings used in this Project. The ultimate strength of the pin insulator assembly shall be equal to the under-mentioned mechanical failing load.

4.3 Dimensions

The Contractor shall guarantee that the dimensions and tolerances of the insulators offered are in accordance with his detailed drawing which shall accompany his bid.

4.4 Markings

Each Pin Insulator shall be marked with the name and trademark of the manufacturer. These markings shall be legible and indelible.

5. TENSION INSULATORS

This specification covers tension insulators for use in strain position on 20 kV, MV overhead distribution system.

5.1 DESIGN AND CONSTRUCTION

The insulators shall be of glazed porcelain.

Each insulator disk offered shall comply with the characteristics and performance requirements set down in the table below.

Characteristics	Requirement
Electrical	
○ Impulse withstand voltage:	100 kV
○ Wet 50Hz withstand voltage:	40 kV
○ Puncture voltage at 50Hz	130 kV
Mechanical	
○ Mechanical failing load	70 kN minimum
○ Mechanical routine load	35 kN minimum
○ Shattered strength	56 kN
Dimensional	
○ Minimum creepage distance	290 mm
○ Standard coupling	Ball and Socket
○ Nominal spacing	146 mm

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Precautions shall be taken to avoid chemical reaction between cement and metal fittings by the choice of suitable materials or by the method of construction.

Cement used in the construction of the insulator shall not cause fracture by expansion or loosening by contraction and proper care shall be taken to locate the individual parts correctly during cementing.

5.2 CORROSION PROTECTION

Ferrous parts, unless of stainless steel, shall be hot dip galvanized.

The minimum weight of zinc coating shall be 0,610g/mm², which is equivalent to a minimum average thickness of coating of 85 microns (µm) with a preference for 1,005g/mm², which is equivalent to a minimum average thickness of coating of 140 microns (µm).

5.3 DIMENSIONS

The Contractor shall guarantee that the dimensions and tolerances of the insulator offered are in accordance with his detailed drawing which shall accompany his bid.

All components shall comply with the relevant Standards.

5.4 MARKINGS

Each string insulator unit shall be marked with the name and trademark of the manufacturer and the year of manufacture. In addition, each unit shall be marked with the specified electromechanical or mechanical failing load in kN. These markings shall be legible and indelible.

6. ACCESSORIES FOR STRING INSULATORS

This Specification covers accessories for a string insulator (excluding insulators) such as: extension link of 200mm, anchor shackle, ball clevis, eye link, socket clevis, eye nut and arcing horn when required.

6.1 TENSION CLAMP ASSEMBLY (WEDGE TYPE TENSION CLAMPS)

Conductor attachment to insulator units at angle, tension and terminal poles shall be made by means of a wedge type tension clamp assembly matching with the conductor material. Each dead-end assembly shall be capable of developing not less than 95 percent of the ultimate strength of the conductor and shall have a conductivity and current carrying capacity of each joint and tension clamp not less than that of an equal length of un-jointed conductor.

The tension clamps shall be delivered with all accessories for two types of clamps, with current loops and without current loop.

6.2 DESIGN AND CONSTRUCTION

All accessories are made of steel.

All parts of accessories for the string insulators offered shall comply with the mechanical characteristics and performance set down in the table below:

Mechanical characteristic	***Requirement***
- Breaking load	70 kN minimum
- Working load	40 kN minimum

- Terminations shall be designed to anchor the bare or covered conductor.
- The different component parts such as: anchor shackle, eye link, socket clevis, ball clevis, eye nuts, extension link shall be designed to connect with above termination and string insulators.

Corrosion Protection: All parts shall be hot dip galvanized.

6.3 DIMENSIONS

The Contractor shall guarantee that dimensions and tolerances of accessories offered are in accordance with his detailed drawing which shall accompany his bid.

All components shall comply with the relevant Standards.

6.4 MARKINGS

Each one of parts of accessories for string insulators shall be marked with the name and trademark of the manufacturer and the year of manufacture. In addition each unit shall be marked with the mechanical load and size. These markings shall be legible and indelible.

7. The Contractor is to supply pin-type insulators and tension insulators.

All insulator units offered shall comply with the characteristics and performance requirements set down in the Technical Data Sheets Q, of Chapter Y. All insulators must be delivered with all accessories necessary for their installation.

Manufacturer's drawings shall be supplied and shall show the outline of the insulators together with all pertinent dimensions.

7.1 MATERIALS

The low voltage insulators are to be of porcelain. The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed. The porcelain surface shall be covered by a smooth and hard glaze, free from cracks and resistant to atmospheric attack.

7.2 DESIGN

The design of insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to its deterioration.

7.3 MARKING

Each insulator shall bear symbols identifying the manufacturer and the year of production.

7.4 PACKING

The packing shall be as per Chapter B General technical Specifications.

7.5 TESTS

As per the relevant Standards.

CHAPTER S

Prestressed Steel Concrete Poles AND ACCESSORIES

CHAPTER P

Surge Arrestors

TABLE OF CONTENT

1. SCOPE

This specification covers the design, manufacture, testing, supply, delivery and performance requirements of pre-stressed concrete poles to be used in the distribution systems of Ministry of Energy and Water of Afghanistan.

The work, which is subject to these specifications, consists of the following:

- The design of the concrete poles in accordance with the specification, including the submissions of calculation as well as design and test criteria.
- The manufacture of all materials and supply in accordance with the delivery schedule.
- The testing and presentation of test data, as set out in these specifications.
- The temporary storage of poles for delivery in accordance with the tentative time schedule.
- The loading, transportation and delivery of poles to the warehouse or storage site designated.

Documents to be furnished by Supplier:

- Outline drawings,
- Technical Particulars,
- The relevant type test certificate in accordance with the applicable standards issued by a national or international acknowledged reputable testing laboratory,
- Technical literature on the equipment,
- Quality control manual for review and acceptance.

2. DESIGN LOADINGS

Each pole shall be able to withstand 2.5 times the design working load in the transverse direction, as indicated in the corresponding drawing.

Each Pole shall be able to withstand an independent load in the longitudinal direction of at least 25% of the transverse loading given above.

The ultimate design load used for designing each class of pole shall be that calculated by applying a point load of 2.5 (factor of safety) times the appropriate standard design working load when the pole is held in the test frame specified in the Clause 9 of the standard.

3. STANDARDS AND CODES OF PRACTICE

Unless otherwise specified, the materials and workmanship specified under this standard shall confirm to the latest version of the appropriate British Standards and SLS as given below;

BS 8110		1985	Structural use of Concrete
BS 12		1991	Ordinary Portland Cement
BS 4449		1988	Carbon steel bars for the reinforcement of concrete
SLS 375		1996	Ribbed steel bars for the reinforcement of concrete
BS 5896		1980	High tensile steel wire and strand for pre-stressing of concrete
BS 882		1992	Aggregates from natural sources for concrete
BS 1881		1993	
	Part	101	Sampling of fresh concrete
		102	Determination of slump
		108	Method of making test cubes from fresh concrete
		110	Method of making test cylinders for from fresh concrete
		111	Method of normal curing of test specimens
		116	Method for determination of compressive strength of concrete cubes
BS 812			Testing of aggregates
BS 4251			Truck type concrete mixer

4. STANDARDIZED TYPES/SIZES OF PRE-STRESSED CONCRETE POLES

The poles shall have square section with uniform variation from base to top.

HEIGHT OF POLE (m)	BURRIED LENGTH (m)	WORKING LOAD (Kg)	PURPOSE	MEW DRAWING NO.
9	1.5	300	LV line	
9	1.5	400	LV line (small angle)	
9	1.5	1,100	LV line (wide angle or dead end)	
12	1.8	500	MV line	S-01
12	1.8	700	MV line, pole mounted transformers, small angle	
12	1.8	1,000	MV line, small angle	

12	1.8	1,800	MV line, small angle
12	1.8	3,200	MV line, wide angle
12	1.8	4,500	MV line, wide angle
12	1.8	6,000	MV lien, wide angle, dead end
15	2.10	1,000	MV line
15	2.10	3,200	MV line
15	2.10	4,500	MV line

5. MATERIALS

5.1 GENERAL

All materials shall conform to the relevant standard specifications referred to in this specification. However, MEW reserves the right to inspect, and if deem to be necessary, to test samples from raw materials stockpiled for use, in any of the contractor's work sites. In the event of such samples not confirming to the standards given herein, MEW may inform same, to the contractor, in writing. On the receipt of such complaint, the contractor shall make immediate arrangements to remove those unsuitable materials completely from the work site, and replace them with materials confirming to the standards, at the contractors own expense.

Manufacturer's test certificates for all reinforcing and pre-stressing steel shall be supplied to the MEW in accordance with the said standards in Clause 3. These test certificates shall show compliance with the relevant standard specifications in all respects and shall be issued by an independent testing laboratory acceptable to the MEW. If the manufacturer's test certificates are not available it shall be the contractor's responsibility for arrange all testing and provide test certificates, before using such materials.

The test information so obtained shall conform to the relevant standard specification. Expenses for same shall be borne by the contractor.

5.2 REINFORCING STEEL

Steel reinforcement shall be one of the following:

a) (i) Hot rolled mild steel round bars complying with BS 4449.
(ii) High yield steel cold worked deformed bars complying with BS 4449.

b) High tensile steel wire for pre-stressing BS 5896

The contractor shall provide to the MEW a certificate for each consignment from the steel manufacturers showing that the steel meets the requirements of the specification. One tension test and one bond test shall be made for each lot of 50 tons.

Steel reinforcing bars shall be free from pitting, loose rust, mill scale, oil, grease, mortar, earth, paint or nay harmful material.

5.3 CEMENT

Portland cement conforming to BS 12 and BS 1370, Part 2 shall only be used for casting of poles under this contract and shall pass the following tests;

i) Fineness
ii) Chemical composition
iii) Compression strength
iv) Setting time
v) Soundness

These tests shall be conducted at the expense of the contractor. Once approved the quality of the cement used shall not be changed without approval of the MEW.

5.4 AGGREGATES

The Contractor shall silt content furnish the following data of aggregate source for approval.

a) Shape
b) Surface texture
c) Silt content
d) Salt content
e) Grading curves
f) Flakiness Index
g) Impact value
h) Water absorption
i) Soundness

The fine and coarse aggregates shall comply with BS 882 - 1992.

5.5 WATER

The water used for the making concrete, mortar and grout shall be clean, fresh and free from injurious amounts of oil, vegetable or organic matter or any other deleterious substance in suspension or in solution. The mix water shall be continuously monitored for salt content and the concrete mix so designed to limit total salt content.

The water should comply with the requirements of BS 3148.

5.6 ADMIXTURES

All admixtures shall comply with BS 5075.

No admixtures shall be added to the concrete mix without prior approval of the MEW.

Any admixtures containing calcium chloride shall not be permitted in the concrete used to manufacture pre-stressed concrete poles.

6. STORAGE AND PROTECTION OF MATERIALS

6.1 CEMENT

Cement shall be stored in a suitable weather-tight enclosure on a broad platform raised off the ground. The enclosure should be such that free circulation of air around the bags of cement is kept to a minimum.

Any cement that has become damp, caked or lumpy shall not be used. Concrete batching operations shall be organized so that cement be used on first-in, first-out basis.

6.2 AGGREGATES

Both fine and coarse aggregates shall be separately stored so that they are kept clean and free from contamination and are not subjected to intermingling. Where a clean hard surface is not available for the stockpiles the bottom 150 mm of the aggregate piles that are in contact with the ground shall not be used.

Heaps of fine aggregate shall be capable of draining freely. Wet fine aggregate shall not be used until; it has drained sufficiently to ensure proper control of the water/cement ratio.

6.3 REINFORCING STEEL

All reinforcement shall be stored clear off the ground on sufficient supports to prevent distortion of bars and in clean dry place. Grease, oil, paint or any other substance that affects the bonding of reinforcement shall not be allowed to come in contact with them. If it does, then all such substances shall be cleaned off from the reinforcement before use. Mild steel, high yield steel and high tensile steel are to be stored separately.

6.4 Pre-stressing Steel

All pre-stressing tendons shall be stored in a clean dry place off the ground and must be kept dry at all times. All loose surfaces, rust, protective oil, or other contaminants that will affect the bond of the tendons shall be thoroughly removed before use. Any part of the tendons that have become pitted, have any tears or nicks, or/permanently deformed or otherwise damaged shall not be used and shall be removed from the site.

7. REINFORCEMENT AND PRESTRESSING STEEL INSTALLATION

7.1 Covers

The **minimum cover** from the outermost reinforcement or pre-stressing steel to the nearest permanent surface of the concrete member, shall be 20mm. All steel shall be accurately placed and shall be held in position during manufacture.

Pre-stressing tendons shall pass through rigidly held guide plates at the ends of members to maintain the minimum covers.

7.2 Spacing

The clearance between two parallel reinforcing bars shall be not less than the greatest bar diameter or, 1.33 times the maximum nominal size of the aggregate or 25 mm.

The clearance between pre-stressing tendon shall be greater than the greater of either four times the nominal diameter of the tendon or 1.33 times the maximum nominal size of the aggregate which ever is greater.

7.3 Stirrups and Ties

The inside diameter of bends in stirrups and ties shall not be less than the enclosed diameter or two times the diameter of the stirrup or tie, whichever is greater.

The ends of the stirrups and ties shall be anchored with a minimum of 90° bend plus a straight 8 times the bar diameters but not less that 65 mm. They shall be firmly attached to the supporting tendons or reinforcement using soft wire ties.

7.4 Welding

Welding or tack-welding of reinforcement will not be permitted.

7.5 PRE-STRESSING TENDON STRESSING

All stressing operations shall be carried out under the direct supervision of a person who is thoroughly experienced with all aspects of pre-stressed concrete construction.

The stressing procedure adopted shall ensure that the force in a tendon increases at a reasonably constant rate. After stressing and anchoring, the force in a tendon shall be the initial force specified in the manufacturing drawings. During stressing the maximum force applied to a tendon shall not exceed 0.8 times of its ultimate tensile strength.

The required amount of pre-stressing force shall be measured by both tendon elongation and jack force or pressure. If the two measurements differ by more than 5 percent then appropriate corrections shall be made.

Tendon elongation shall be calculated from the actual load/elongation graphs supplied by the steel manufacturer. Appropriate anchorage-draw-in shall be accurately assessed and allowed for. A correction shall be applied to the total elongation observed to compensate for any initial tensioning of the tendon applied to take up irregularities and slackness. Jack and anchorage friction shall be assessed and an appropriate correction made to the jacking pressure.

Records shall be kept for the following stressing operations,

a. Amount of tendon elongation up to the stage of anchoring the tendon
b. Allowance for anchorage-draw-in
c. Jack force at anchorage
d. Allowance for jack friction
e. Manufacturer's identification mark for pre-stressing tendons used.
f. Date and time of stressing
g. Date and time of de-stressing
h. Curing sequence and concrete strength at time of de-stressing
i. Identification mark placed on each particular pole

The jacking force shall be measured to an accuracy of one-in-forty

Pre-stressing force and the tendon elongation to an accuracy of 2 mm.

If the tendons are stressed then left for more than 2 weeks before being fully surrounded with concrete they shall be removed from the moulds and discarded.

Pre-stressing equipment shall be maintained in a serviceable condition and its calibration and accuracy checked every 3 months.

7.6 DE-STRESSING

The transfer of pre-stress into the hardened concrete shall take place gradually and in such a determined order that tensile stresses sufficient to cause cracking are not induced in the concrete. Immediately after de-stressing the maximum stress in the tendons shall not be exceed 0.75 the ultimate tensile stress of those tendons.

If all the tendons are not to be released simultaneously then prior approval for releasing sequence shall be obtained from the MEW.

Any releasing device shall be so designed that during the period between stressing and de-stressing the tension in the pre-stressing tendons does not alter. It shall also be designed so that there is no increase in the stress in the tendons above the stress level in the tendons just prior to de-stressing.

7.7 DE-BONDING OF TENDENS

Where a tenden or a number of tendens has to be de-bonded at a certain length as specified in the corresponding drawing, the particular tenden(s) shall be fully covered for the total de-bonded length only, using a plastic sheath. Application of grease onto the tendens for de-bonding is not allowed.

7.8 CUTTING AND FINISHING OF TENDONS

After de-stressing is completed the ends of the tendons shall be cut off flush with the surface of the concrete.

If flame cutting is used there shall be an excess of oxygen in the flame and the cutting shall take place as rapidly as possible.

The ends of the poles shall be finished with a cement plaster (1:3 or richer) to a thickness not less than 25 mm after flush trimming the tendons. An epoxy paint to be applied to the top and bottom surfaces after cement plastering.

8. MIXING, PLACING AND CURING CONCRETE

8.1 MIX DESIGN

Concrete used for casting of poles shall be of grade 40 and shall posses the following minimum qualities as per BS 5328.

i) Minimum cement content - 325 kg/m3
ii) Maximum free water-cement ratio - 0.55
iii) Minimum strength at an age of 28 days - 40N/mm²
iv) Nominal maximum aggregate size mm - 20

Full details of the components forming the concrete mix proposed to be used by the Contractor shall be submitted to the MEW for approval **at least 2 weeks before any concreting operations are commenced.** Once the proposed mix has been approved it shall not be varied by the contractor without prior approval.

The concrete mix shall be designed and tested and their submission shall include the following information.

a) Source, nature and gratings of both the fine and coarse aggregates.
b) Type and supplier of the cement to be used
c) Proportions by weight of fine and coarse aggregates
d) Weight of cement per cubic meter of concrete.
e) Water-cement ratio by weight
f) Estimated slump of the mix
g) Arithmetic mean compression strength of the mix at 7 days and 28 days using either cylinder compression test or cube compression samples plus the standard deviation of the test strengths of the number of cylinders and cubes tested.
h) Any admixtures used

The ratio of the weight of the fine aggregates (sand) to the total weight of aggregates shall be between 0.35 and 0.50. All testing costs shall be borne by the contractor.

8.2 READY-MIXED CONCRETE

Ready-mixed concrete as defined in BS 2426, batch off the site, may be used and comply with all requirements of this standard.

The ready mix concrete shall be carried in agitators, operating continuously or truck mixers made for this purpose. The concrete shall be compact in its final position within 1 hour of the introduction of cement to the aggregates. The time of such introduction shall be recorded on the delivery note together with the weight of the constituents of each mix.

When truck-mixed concrete is used, water may be added under supervision, either at the site or at the central batching plant, but no water be added in transit.

Mixing and discharge performance of truck mixer units shall comply with the requirements of BS 4251. Mixing shall continue for the number and rate of revolutions recommended in accordance with BS 4251, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.

8.3 CONCRETE MIXING

All concrete shall be mixed in weigh batch mixing machines. The machine shall have a large water storage tank with a gauge so that a predetermined quantity of water can be injected direct into the mixer drum.
The dry concrete shall be mixed until a uniform color is obtained. After the addition of the water the concrete shall be mixed until a uniform color is achieved. The total water in the mix shall not exceed the amount used in the trial mix.

Water contents of the aggregates should be considered in determining the quantity of water to be added. The amount of water shall be sufficient to ensure through hydration, good workability and high strength.

8.4 WORKABILITY

The consistency of the concrete shall be such that it can be readily worked into the corners and angles of the formwork and around reinforcement without segregation of the materials or bleeding of free water at the surface. On striking the formwork it shall present a face which is uniform, free from honeycombing, surface crazing or excessive dusting. The workability of the proposed mix in the various grades is adequate for the requirements of the specification. The contractor shall carry out workability tests on the preliminary trial mixes required elsewhere. These tests shall be carried out in accordance with BS 1881, or any other applicable standards.

The samples to be tested shall be obtained from the batches used for the preliminary test cubes. The mould shall be filled in the presence of the MEW representative with concrete from which the preliminary test cubes are made and shall be compacted in the same manner with the same equipment as proposed for the works. This procedure shall if necessary, be repeated with modified mixes until the appearance of the concrete after striking the mould is acceptable to the MEW, after which it shall be used as the standard for that grade.

When a specific workability is called for a check shall be maintained by measuring slump at the rate of one test for each 10 cubic meters of concrete or three tests for each day of concreting.

8.5 TRANSPORT OF CONCRETE MIX

The concrete shall be discharged from the mixer and transported to the works in such a way to as to prevent adulteration, segregation or loss of ingredients, and ensure that the concrete is of the required workability at the point and time of placing.

8.6 PLACEMENT AND COMPACTION

Placement rate of concrete shall be such that concrete is at all times plastic and flows readily into the space between reinforcements. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the moulds, nor shall re-tempered concrete or concrete that has been re-used after initial set be used.

The placement of concrete in the moulds shall be completed within half an hour after the introduction of water to the cement and aggregate in the concrete mixer. Each mould shall be filled with concrete in continuous operation. Construction joints will not be permitted in the poles. Should there be an interruption during the placement of concrete into the mould such pole shall be discarded.

All concrete shall be consolidated in the moulds using high frequency internal or external vibrators. The amount of vibration shall be uniform along the length of the mould and shall be carefully controlled so that adequate consolidation is achieved without segregation of the concrete mix by over vibration.

8.7 PROTECTION AND CURING OF CONCRETE

During the initial stages of hardening the concrete shall be protected from the direct rays of sunlight and from drying winds. The moulds containing the hardened concrete shall not be disturbed or shifted unless it is made sure that such movements will not damage the cast.

8.7.1 Moist Curing at Ambient Temperature

All surfaces of the pole exposed to the atmosphere shall be kept constantly wet or damp for at least 7 days after casting. Concrete manufactured from type iii cement (high early strength) shall be moist cured at least for 4 days.

8.7.2 Curing at Elevated Temperatures

Curing at elevated temperatures is permitted subject to the following precautions.

i) Adequate means shall be provided to prevent moisture loss from the concrete from the time of initial set to the end of the elevated temperature curing cycle.

ii) An initial maturing period shall be allowed before any increase of ambient temperature. This maturing period shall be measured from the time of completion of casting and shall be such that the product of time and ambient temperature at the place of casting the concrete is not less than 40°C hours (eg. 2 hours at 20°C = 40°C hours). During this maturity period the surface of the concrete shall not exceed 30°C.

iii) All pins and other fitments which pass through the mould and concrete shall be withdrawn after initial maturing to prevent damage to the concrete caused by differential expansion between the mould and the concrete.

iv) After initial maturity heat may be introduced to the concrete at a rate that limits the temperature rise to a maximum of 24°C per hour. Under no circumstances shall the temperature rise during any 15 minutes exceed 6°C.

v) The temperature during the curing cycle shall not exceed 75°C.

vi) The rate of cooling of the concrete and the removal of any steam covers, blankets etc., shall be controlled prevent any damage due to thermal shock or differential cooling.

vii) The heat source shall be well distributed to ensure that a uniform temperature distribution exists in the concrete and no local overheating occurs to the concrete, the pre-casting moulds or to any test specimens.

viii) Concrete test specimens shall be cured exactly in the same manner as the concrete poles.

Temperature records shall be as follows, during curing at elevated temperature.

a) The temperature during the initial maturing period
b) Temperature at ½ hourly intervals during the temperature rise period.
c) Temperature at 2 hourly intervals during the maximum constant temperature period and at the end of this period after shutting off the heat source.

Elevated temperature cured concrete poles shall be moist cured for further 4 days at ambient temperatures. During this period all surfaces of the pole exposed to the atmosphere shall be kept constantly wet or damp.

9. HOLES AND GROUND WIRE

The fixed position and size of the holes are specified and shown in the respective drawings and will be reconfirmed during contract negotiations and/or approval of drawings by MEW and/or their appointed representative.

Preferably, holes shall be casted during the fabrication of the poles using tubes which shall be accurately located on the poles outlines. Drilling is permitted as long as no damage is done the reinforcing steel, pre-stressed steel cables, concrete pole face (interior/exterior), or embedded copper ground wire.

Earth terminal base (grounding nut) and connections should be provided and fixed to specified points on the poles as outlined in the respective drawings.

Each pole shall have embedded in the concrete, clear of any holes, for LV pole 25 mm^2 and for MV pole 35 mm^2 - stranded soft drawn copper ground wire. This ground wire shall be bonded with a suitable bimetallic electrical connector to the steel strand between the two ends of the pole. Details of the earthing system and its connection to the medium & low voltage system, of the plastic outlet tube to connect the ground wire to the ground rod, etc. shall be as shown in the MEW's Distribution Standards.

10. CONCRETE SAMPLING AND TESTING

10.1.1 General

A random sampling procedure, to obtain the samples for compression strength tests of concrete has to be adopted the minimum frequency of sampling of the concrete shall be (01) one sample per (50) fifty poles, but not less than one sample per day, whichever is higher. "Casting of Samples" is described in Cl. 10.1.2. Contractor shall make arrangements to carry out the compression strength test as per BS 1881, for each of above samples, at an independent testing laboratory.

The concrete shall be considered acceptable when the test results are in accordance with 4.0 of BS 5328. The cost of these tests shall be borne by the contractor.

In the event the above tests results are not in a accordance with the relevant standards the poles so manufactured shall be rejected.

10.1.2 Casting of Samples

Samples for compression strength tests shall be molded in 150mm cubes, 100mm diameter x 200mm high cylinders or 150mm diameter x 300mm high cylinders. The date of casting of the sample shall be clearly and indelibly marked on the fresh concrete. Subsequent marking on freshly applied motor/grout layer is not allowed.

A sample shall consist of 4 cubes or cylinders made concurrently from the same batch of concrete. Two of the cubes or cylinders shall be used to establish the 28 day compression strength and the other two of the cubes or cylinders shall be used to establish the rate of gain in strength approx. 7 days of the concrete before de-stressing the tendons.

All samples shall be taken molded and cured in accordance with the procedures in BS 1881 and except that cylinders or cubes taken to check the rate of gain of compression strength before 28 days shall be cured in the same manner as the concrete poles from which the samples are taken.

10.2 Compression Strength Tests

Testing of the compression strength samples shall be carried out in accordance with the procedures in BS 1881.

The minimum required 28 day cylinder compression strength of all concrete used to manufacture concrete poles shall be 40 N/mm².

The minimum required cylinder compression strength before the transfer of any pretress force into the concrete is permitted should be 30 Mpa.

10.3 Acceptance Criteria for Compression strength

The concrete shall be considered acceptable when tested and found satisfactory according to stipulations in B.S. 5328 Part 4.

10.4 Cost of Testing

All testing shall be carried out in an approved independent testing laboratory at the expense of the contractor in accordance with standards specified.

10.5 Pole Moulds and Surface Finishes

Moulds shall be designed, constructed and finished to ensure that they can be removed without damaging the hardened concrete, and shall be securely braced and supported to prevent sagging and bulging during the deposition of the concrete. Joints in the materials used to manufacture the moulds shall be tight and shall not permit any leakage of cement paste from the concrete mix. Retaining pins which form bolt holes in the finished pole shall be provided with flexible seals or some similar means to prevent the loss of any cement paste from the concrete mix.

All poles shall have a smooth, hard, uniform in color surface finish and free from any honey combing and air pockets not exceeding 4mm in diameter. All fins and other projections shall be rubbed down or ground flush with the general surface of the pole.

Repairs to defective casting will **not be permitted** and any pole of such nature will be **rejected**.

10.6 Dimensional Tolerances

Recommended dimensional tolerance shall be as follows:

Length	± 15 mm	(allowance shall be made during design for length reduction to pre-stress).
Cross Section	+ 4mm - 2mm	(Overall dimensions and dimensions of parts such as webs etc.)
Straightness	± 15 mm	(Deviation from a straight line joining the top and the widest dimensions at the butt)
Holes sizes	- 0 + 2	
	± 5 mm	relative position

Location of Reinforcement ± 3mm (but specified covers shall not be reduced)

Any poles with dimensional deviations falling short, of the aforesaid will be rejected.

10.7 MARKING OF POLES

Following data of the pole should be clearly and indelibly marked at a position approximately 1.80m above the ground level, by **embossing** the marks on **fresh** concrete, just after the casting of pole. Subsequent marking on cement motor/grout applied **later** into the pole is **not** allowed.

a) Date of manufacture, Identification Mark of Manufacturer and the Serial No. of the Pole - No two poles belonging to same manufacturer could bear the same Serial Number.

b) **Length of pole** in meters and its **design working load** as defined in this Specification - for example a 9 meter pole with a 300 kg working load shall be marked as 9/300, as indicated in the relevant drawing.

10.8 LIFTING, HANDLING AND SHIFTING

Poles shall not be lifted or handled until the concrete has attained strength of not less twice the stress induced by the methods of handling and lifting. Pole shall be held from at least two points while lifting.

Pole shall be transported on vehicles that provide full-length support without any over hang.

Any pole that shows signs of any damage shall be rejected.

While lifting and shifting major axis of the pole shall be kept in vertical position.

11. POLE LENGTH AND SHAPE

11.1 GENERAL

The pole shape shall be vireendel section conforming to details on corresponding drawing and shall have a tapering section from bottom to top. The manufacturer shall submit a detailed description of the method of pole fabrication including the details of moulds.

All bolt holes shown on corresponding drawing shallbe cast into the pole.

12. INSPECTION & TESTING OF POLES

12.1 GENERAL

The MEW reserves the right to inspect plant and machinery and raw materials used for the manufacture of poles. At any time the contractor shall provide access to the plant to the MEW representative. Facilities as necessary, free of charge, labor, gauges, tools, materials testing equipments etc. for testing and inspection of poles shall be provided by the Contractor.

The MEW reserves the right to reject any pole, which does not confirm to the MEW standard.

12.2 TESTING OF POLES

One-in-hundred of each type of poles selected at random will be tested in the following manner.

A pole shall be tested in the horizontal position only. Pole shall be fixed in such a way that there is absolutely no movement during the process of loading, in the bottom part of pole between butt-end and the line of testing. (See Technical Specification for Acceptance Test of Concrete Poles)

For horizontal testing, provision may be made by suitable supports to neutralize the bending moment induced by the weight of the pole.

"Apply the test load at a point 0.60 m from the top of the pole and raise it in increments of 10% of the ultimate load. Take measurements of deflection after each increment of 10% of the ultimate load. At 40% and at 60% of ultimate load reduce the load to zero and measure the permanent set. Then increase the load in steps of 10% of the ultimate load until failure occurs, maintaining each load above 60% of the ultimate load for at least two minutes (failure load is the load at which the dynamometer indicates no further increase in load)".

The whole batch of 100 would be acceptable to the MEW, if the tested pole passes the criteria given in (a), (b), (c), (d) and (e).

a) During the application of load up to 40% of the ultimate load, the pole shall not have developed any hair cracks.
b) The permanent set recorded, after removal of a test load of 60% of ultimate load shall not exceed 10% of the deflection recorded for same test load.
c) The hair cracks produced while loading up to 60% of the ultimate load, shall clearly close up on removal of the test load.
d) The test load at failure shall exceed the ultimate load.

e) On breaking the concrete after failure it shall be established that the following requirements are in accordance with the corresponding drawing/specification of Pole.

i) Type, diameter, length number of bars and positioning of the main reinforcement.

ii) Type, diameter, shape and spacing of stirrups.

12.3 FAILURE TO SATISFY ACCEPTANCE CRITERIA

In the event that a pole does not satisfy any of the above acceptance criteria for the type tests, then one more pole shall be tested for all the five acceptance criteria. If additional pole tested fails to satisfy the acceptance criteria then the entire batch shall be rejected. All the poles rejected shall be marked with permanent ink, of at a distance of 2.5 m from the bottom of the pole and removed from the site immediately.

12.4 The cost of testing shall be borne by the contractor. This also includes the cost of poles used for testing.

13. TRANSPORTATION

13.1 TRANSPORT TO SITE

They shall be transported on vehicles that provide full-length support without any overhang.

Any poles that show sign of damage shall be rejected and shall be removed by the Contractor.

While transporting the major axis of the pole shall be keptin vertical position.

13.2 LIFTING AND STORAGE

Poles shall only be lifted by the points designated on the manufacturing drawings and when stacked at the manufacturing plant or at the point of delivery shall be separated by timber bearers placed between each unit at the designated lifting points. Timber bearers shall be placed only on lines vertically above each other. Poles shall be stacked such that the major axis of the pole will be kept in the vertical position.

TABLE OF CONTENT

1.0 SCOPE

This Standard covers the testing **pre-stressed** concrete poles :

2.0 WITNESSING OF TEST :

2.1 INSPECTION OFFICER (PROJECT MANAGER)

The witnessing of test shall be carried out by a suitable officer nominated by the Ministry of Water & Power (MWP) herein after called the "**Project Manager**". The Project Manager who witnesses the tests shall totally satisfy himself that the poles are tested strictly in accordance with the guidelines given in this Standard.

The Project Manager shall have the right to inspect the manufacturing plant, machinery and raw materials used for manufacture of poles at any time which is deemed to be necessary.

2.2 TEST APPARATUS

Testing of poles shall be done in a testing bench using contractors' own testing equipment/apparatus. The Project Manager should thoroughly inspect the testing equipment **before any testing commences** and totally satisfy himself that all the equipment is in perfect order and as per the requirements given in Clause 5.1.3 to 5.1.6. The contractor shall rectify any inaccuracy in the test apparatus and replace unsuitable test equipment to the satisfaction of the Project Manager before any test commences. The Project Manager has the right to request for the calibration reports of the equipment involved in the testing. The However Project Manager reserves the right to use a dynamometer belonging to the MWP, if deem to be necessary.

3.0 SELECTION OF SAMPLES FOR TESTING :

3.1 BATCH OF POLE

Every **100** poles or part thereof is considered a batch of poles. the contractor shall submit the following details of the batch of poles at least two weeks before the testing is arranged :

1) Type of Poles
2) Lot Number
3) Dates of Casting
4) Serial Numbers

3.2 INSPECTION OF BATCH OF POLE

The contractor shall arrange the batch of Poles ready for testing in such a manner that visual examination is easy and markings, serial numbers etc. with hole positions are easily seen. Whole batch of poles shall be fully matured and even the last pole of that particular batch should have passed the 28th day of maturing before testing.

Following visual inspection shall be carried out by the Project Manager before selecting a test pole.

a) Random overall, dimensions shall be checked and the hole positions, hole size and straightness shall be in accordance with the MWP Standard Pre-stressed Poles. Dimensional tolerances for the above shall comply with the values given in Clause 3.2.1 below for Pre-stressed Poles.
b) Reinforcement bars or stirrups shall not be exposed.
c) The poles shall be of a good finish and free from honeycombing and shall be of a neat appearance.
d) The poles shall be properly marked as per Clause 3.3 below.

Any individual Pole/Poles which are not complying with one of the above physical parameters shall be rejected. However, this will not affect the acceptance/rejection of the remaining poles in the particular batch of poles to be tested.

3.2.1 Dimensional Tolerances

The permitted variation from a stated dimension or cross sectional shape of the finished pole and hole positions shall be as follows:

Length: ± 15 mm
Cross Section Overall dimensions and dimensions of parts such as webs etc.: + 4mm, - 2mm
Straightness Deviation from a straight line joining the top and the widest dimensions at the butt: ± 15 mm
Holes Size: - 0, + 2 mm
Relative position: ± 5 mm

Location of Reinforcement ±3mm but specified covers shall not be reduced

3.3 MARKINGS

The following markings in accordance with MWP Standard Pre-stressed Poles shall have been embossed on each pole during casting.

i) Letters "MWP"
ii) Pole size and working load

iii) Date of casting
iv) Serial No. of the pole
v) Name/Identification No. of manufacturer

Marking the poles **subsequent** to casting (on freshly applied grout/mortar layers) shall not be allowed. Any pole so marked shall neither be considered for testing, nor be recommended for purchase by MWP.

In addition to the above a horizontal line (testing line) shall be marked at a point as indicated in Clause 4.0 of pre-stressed poles, and particular drawing.

No **two** poles manufactured by one and the same contractor can bear the **same** serial number.

3.4 SELECTION OF POLES FOR TESTING

The contractor shall produce the full batch of poles for inspection by the Project Manager who, **himself** has to select **randomly** among the whole batch, the required pole for the test. The batch of poles produced shall be stacked and necessary arrangements shall be made by the Contractor so that **any** pole selected by the Project Manager could be drawn out for testing.

In case the test pole fails, the pole to be tested again also shall be selected in the same manner.

4. STANDARDIZED TYPES/SIZES OF POLES

HEIGHT OF POLE (m) BURIED LENGTH (m) WORKING LOAD (kg) TESTING LINE FROM THE BUTT END (mm)

HT OF POLE (m)	BURIED LENGTH (m)	WORKING LOAD (kg)	TESTING LINE FROM THE BUTT END (mm)	DRAWING NO.
9.0	1.5	300	1,500	
12.0	1.8	600	1,800	
12.0	1.8	700	1,800	S-01
12.0	1.8	850	1,800	
15.0	2.1	600	2,100	
15.0	2.1	900	2,100	

5.0 TESTS TO BE CARRIED OUT :

5.1 Type Test

5.1.1 General

This is a destructive test, carried out to check whether the batch of poles conform to the design requirements, set out in the MWP Standards.

Once the manufacture of poles in a contract has commenced, a minimum of one pole for each batch of **100** poles or part thereof manufactured has to undergo this test. Selection of pole/additional poles for this test shall be done as stated in Clause 3.4. Acceptance criteria for this test are given in Clause 5.3.

5.1.2 Testing Arrangement

Testing arrangement shall be horizontal where the pole is supported in horizontal position on roller tracks as indicated in the Drawing No. S-06 annexed in Chapter Z. Vertical arrangement is **not** recommended for testing of concrete poles.

5.1.3 Test Apparatus

The contractor shall arrange test apparatus of his own, as per requirements given in Clause 2.2 for horizontal testing arrangement.

5.1.4 Loading of Pole

The loading of the pole shall be effected by applying suitable standard/calibrated weights, or any other tensioning equipment approved by the Project Manager. However, due to the friction of pulleys and cables, 100% of the actual weight used for loading, will not be transferred to the pole, as such, a **dynamometer shall** be connected to the loading system **just before** the point of loading of the pole, in order to read the exact value of load transferred to the pole. Loading shall be transferred to the pole through a hook made of flat iron not more than 50mm width, going round the pole exactly at 0.6 m below the top end of pole.

It is very important to place the pole in correct orientation, on the test bed, so that the end loading is applied in a **transverse** direction of the pole. The distance of pulley located horizontally away from pole shall not be less than twice the height of pole to ensure an angle of 900 between the rope and test pole, while the pole is subject to deflection.

5.1.5 Supporting the top part of Pole

When the pole is tested in horizontal position, the length of it beyond the points of fixing (i.e. length above the testing line) shall be properly supported on a bed of roller tracks, so that the effect due to the self-weight of the pole is neutralized. These roller tracks shall be friction free as much as possible and offer no resistance to the lateral movement of the pole.

The length not more than 150mm and the diameter not less than 30mm galvanized Iron pipes may be used as rollers. Rollers shall be mounted on a channel iron frame using ball bearings. These rollers have to be attached to the above frame in such a way that the top surface of those rollers are located in an exactly horizontal plane, and all the rollers are absolutely free to move. (construction of a roller track is indicated in the drawing). The roller track frames shall be placed on a cement rendered continuous pavement, which shall be exactly horizontal, in order to prevent any relative settlement of them during loading.

A minimum number of 03 roller track units shall be used spaced equally between the pole testing line and a point just before the application of load of the test pole.

However, the number may be limited to 2 for poles of 6m. height. Before any testing commences, the Project Manager has to inspect the movement of the trolleys and totally satisfy himself that they are friction-free and do not offer any resistance to the horizontal movement of the pole during loading or unloading.

In case of poles which are having a tapering section along the narrow face also, the two roller tracks close to the top end of pole shall be provided with suitable means in order to compensate the height difference arising due to the variable section.

5.1.6 Fixing the Pole at Butt End

Pole shall be properly fixed at the butt-end using a suitable arrangement. Important requirements in this arrangements are given below :

i) Pole shall be fixed in such a way that there is absolutely no movement during the process of loading, in the bottom part of pole between the butt-end and the line of testing (level of fixity)

ii) The balance length of pole shall be absolutely free to move in the lateral direction ie., the fixing shall be done only between the butt end and the line of testing.

A typical arrangement of a horizontal testing apparatus is shown in Drawing annexed. In this arrangement fixing of butt-end is done by resting it on a concrete/steel bed as shown in the drawing. Tightening shall be done using wooden/steel wedges of appropriate size placed in between the pole and the steel/concrete base, in order to fix the pole properly.

The arrangement shown in the drawing shall be used for any of the pole sizes to test Pre-stressed Poles as shown in the corresponding figure in the Drawing. It is important to note that, as the position of the pulley through which the load is applied is fixed, any pole that is tested shall be positioned in such a way that the top of the pole is only 0.60 m beyond the point of loading. Butt end of poles of different sizes shall be fixed by tightening with wooden/steel wedges. Before the test load is applied, 10% of the ultimate load shall be applied to the pole and released there after tightening the wedges to ensure fixity of the butt end of pole.

5.1.7 Testing Procedure

Pole shall be held rigidly between the butt end and the testing line. Specified in the corresponding pole drawing. Method of fixing the butt end is described in Clause 5.1.6.

Before starting the test, Project Manager shall inspect the testing arrangement and confirm whether all the requirements mentioned in previous Clauses with regard to the testing arrangements are met with. After this, the loading of the pole shall be commenced.

Loading shall be applied at a point 0.6m below the top of the pole for any type of pole. Initial loading shall be 10% of the ultimate load. Ultimate load is obtained by multiplying the working load indicated in the corresponding drawing of pole by a factor of 2.5. Loading shall be raised by increments of 10% of the ultimate load. Measurement of the deflection of the top end of the pole shall be recorded for each increment of load. These measurements shall be taken with the help of a pointer and ruler. Also pole shall be carefully observed at every 10% increment of loading for formation of hair cracks and it shall be recorded properly (A specimen pole test recording sheet is attached as Annex B). For the purpose of recording hair crack measurements shall be made from the but-end of the pole.

After applying 40% of the ultimate load, the loading should be reduced to zero, and the permanent set of the top of the pole shall be measured.

Increase the loading again, starting from zero in 10% increments, carefully observing the formation of hair cracks, if any, on the surface of the pole, until 60% of ultimate load is applied, and then again loading shall be reduced to zero, and the permanent set shall be measured, and recorded. For each step of loading, deflection of the top end of pole and the formation of hair cracks on the pole, if any, shall be recorded.

After the removal of 60% of the ultimate load, pole shall be carefully examined and verified whether all the hair cracks formed during loading have been **completely closed** and observations shall be recorded.

Loading shall be increased again from zero in steps of 10% of ultimate load and measurement of deflection shall be taken after each increment, maintaining each load above 60% of ultimate load for at least 02 minutes, until complete failure of the pole occurs. Also hair cracks shall be observed and recorded.

After the failure has occurred, the Pole shall be removed from the test bed, and concrete has to be broken sufficiently from any place/places as required by the Project Manager, and the reinforcements and stirrups should be exposed. Reinforcement should be carefully examined and verified whether the following factors are meeting the requirements of relevant drawing/specification.

i) Type, diameter, length, number of bars and positioning of the main reinforcement.
ii) Type, diameter, shape and spacing of stirrups.
iii) Length and correct positioning (staggered) of lap joints.

5.2 Recording of Observations

All testing shall be carried out by the Contractor, but all aspects shall be observed by the Project Manager.

A typical format for recording of observations is shown in Annex - 2.

The remarks column of the format generally is meant for the recording of the opening of hair cracks under loading, and their closure under the release of load. However, any other remarks which Project Manager, considers worth recording, could be entered in it.

5.3 Acceptance Criteria

5.3.1 Test Results

Any pole subjected to the type test mentioned above, shall satisfy all the five acceptance criteria mentioned below.

i) During the application of load up to 40% of the ultimate load, the pole shall **not** have developed any hair cracks.
ii) The permanent set recorded, after removal of a test load of 60% of ultimate load shall **not** exceed 10% of the deflection recorded for same test load.
iii) The hair cracks produced while loading up to 60% of the ultimate load, shall clearly **close up** on removal of the above test load.
iv) The test load at failure shall **exceed** the ultimate load.
v) On breaking the concrete after failure it shall be established that the following requirements are in accordance with the corresponding drawing/specification of Pole.

a) Type, diameter, length, number of bars and positioning of the main reinforcement.

b) Type, diameter, shape and spacing of stirrups.

c) Length and correct positioning (staggered) of lap joints.

5.3.3 Acceptance

If the test pole satisfies **all** the acceptance criteria given in Clause 5.3.1 the batch of 100 poles shall be acceptable, except the test pole and poles rejected at visual inspection (Clause 3.2). Rejected pole/poles shall be marked with permanent ink in the presence of the Project Manager and removed from the site immediately. Project Manager has to make note of the serial numbers of the poles rejected in the test report.

If the test pole fails to satisfy any **one** or more of the acceptance criteria, then one more pole from the same batch shall be selected as per Clause 3.2 to be tested again. If that pole satisfies **all** the acceptance criteria, then the batch shall be acceptable except tested poles and rejected poles. If that pole also fails to satisfy any **one** or more of the acceptance criteria, then the entire batch shall be rejected. The entire batch rejected shall be marked with a permanent ink, in the presence of the Project Manager, and removed from the site immediately. Project Manager has to make a note of the serial numbers of the poles rejected in the test report.

5.4 COST OF TESTING

The cost of poles tested as well as all the above testing shall be born by the Contractor.

5.5 POLE TRANSPORTATION

Depending on the contract, poles that are accepted by the Project Manager may be transported to the site or handed over to a MWP Officer at the contractor's work site. Taking Over Officer shall have right to reject any pole/poles that are damaged/which have developed cracks before taking over. Rejected poles shall be removed from the site immediately. MWP Officer has to make a note of the serial numbers of such poles in the delivery note issued by the contractor. Delivery notes shall be dully signed by the MWP Officer after making the necessary remarks.

6.0 ATTACHMENTS

Pole Test Report

Annex - 1

My No. ....
Branch ....

POLE TEST REPORT

NAME OF THE CONTRACTOR & PLACE OF SITE : ....
....

DATE OF TESTING : ....
TYPE OF POLE : ....
WORKING LOAD : ....
FACTOR OF SAFETY : ....
ULTIMATE LOAD : ....
PLACE OF TESTING :...
SERIAL NO. OF THE TEST POLE : ....
SERIAL NOS. OF BATCH OF POLES FROM .... TO ....
MWP STANDARD 044-3 : 1996

INSPECTION OF POLE BATCH :

(a) Whether all the poles satisfied the visual inspection criteria given in Clause 3.2 ....
If not,

(b) Following poles have been rejected due to non-conformity to aspects mentioned herein.

Serial No.	Pole Height	Cross Section	Hole Position	Hole Size	Straight-ness	Finishing	Pole Marking	Remarks

TEST POLE :

a) SERIAL NO. : ....

b) DATE OF MANUFACTURE : ....

STAGE	LOAD APPLIED IN kg.	% OF ULTIMATE LOAD	DEFLECTION IN mm	REMARKS
1		0		
2		10		
3		20		
4		30		
5		40		
6		0		
7		10		
8		20		
9		30		
10		40		
11		50		
12		60		
13		0		
14		10		
15		20		
16		30		
17		40		
18		50		
19		60		
20		70		
21		80		
22		90		
23		100		
24		110		
25		120		
26		130		

27		140		
28		150		
29		160		
30		170		
31		180		
32		190		
33		200		

1. Whether any hair crack/cracks developed during the application of load up to 40% of the ultimate load : ....
2. Whether the hair cracks, produced while loading up to 60% of the ultimate load, have closed. : ....
3. Permanent set after 60% of the ultimate load : ....mm
4. Test load at the destruction of the pole : ....kg.
5. Verification of reinforcement after breaking of the concrete of the tested pole

   a) Main Reinforcement
      (1) Type .... (2) Diameter ....mm (3) Lap length ....mm
      (4) Lap positioning ....

   b) Stirrups
      (1) Diameter ....mm (2) Spacing ....mm

Whether the tested pole satisfied the acceptance criteria : ....

If not what is the pole No. selected for second test : ....

In view of the above this batch of poles is accepted/rejected with the exception of the rejected pole/poles mentioned in page 01 of this report and the tested pole

Name and Designation of MWP
Testing Officer/Project Manager : ....

Signature : ....
Tested in the presence of
(Name of Contractor or his Agent) : ....
Signature : ....
Date : ....

TABLE OF CONTENT

1.0 SCOPE

This specification covers the general requirements of the manufacture and testing of Galvanized Steel Cross Arm Assemblies of the following types for use in the construction of medium voltage (20kV) overhead distribution power lines.

2.0 APPLICABLE STANDARDS

The cross arm assemblies supplied shall be in accordance with the latest editions of the standards specified below.

a) BSEN 10113-2 (1999#0 – Weld able fine grain structural steel.
b) B.S. 4360 (1990) – Weld able structural steel
c) B.S. 4848 Parts IV & V - Hot rolled structural steel sections
d) B.S. 464 (1998) - Thimbles for wire ropes.
e) BSENISO 1461 (1999) - Hot dip galvanized coating on iron and steel articles.

3.0 BASIC FEATURES

The cross arm assembly shall consist of three parts such as angle iron cross arm, flat iron bracing and iron channel for transformer pole mounted.

3.1 GRADE AND QUALITY OF STEEL

The grade of steel used for the fabrication of cross arm assembly shall be 43DD as per BS 4360 or 355N as per BSEN10113. The dimensional tolerance on flat iron and angle iron shall be as stipulated in BS4360 / BSEN 10113 and BS 4848 Part 4 respectively. The minimum thickness of the angle iron shall be 7 mm and for channel iron shall be 6mm. The chemical composition of the steel used shall be as stipulated in BS 4360 / BSEN10113 (Table 14 and Table 1 respectively)

The steel used for the fabrication of cross arm assembly shall be sound and free from any internal and external defects or surface flaws, which might preclude its use for the purpose for which it is intended.

3.2 MECHANICAL PROPERTIES

The mechanical properties of steel including the minimum Tensile Strength Yield Strength and Elongation shall be as stipulated in BS 4360 /BSEN 10113 (Table 15 and Table 3 respectively).

3.3 FABRICATION

Cross arm assembly shall be fabricated out of following types of steel sections manufactured in accordance with BS 4360 : 1990 / BSEN 10113 structural steel.

a) Angle iron section 70 x 70 x 7m (for crossarm)
b) Channel Iron section of 120mm x 55mm x 7mm (for substations pole mounted)
c) Flat Iron section of 40 mm x 8mm (for bracing)

The manufacturer shall have all equipment necessary to carry out shot / grit blasting, punching, shearing/cutting, forging, welding and bending operations in the place of manufacture and shall have facilities and capability to supply the quantity as indicated in the schedule of prices.

The channel iron, flat iron and angle iron sections shall be first cleaned and made rust free by shot / grit blasting, then necessary holes punched, cut in to required sizes, then welding, bending, forging and identification marking (as per Clause 5.1) shall be carried out. All components of the cross arm assemblies shall be hot dip galvanized conforming Chapter B General Technical Specification.

Position and size of holes on the cross arms, bracings and channel iron shall be precisely in accordance with the drawing annexed.

3.4 DRAWINGS

Cross Arms Assembly shall be in strict accordance with the Specifications and as per drawings indicated below.

a) Tension cross arm assembly as per drawing No. S-07.
b) Flat iron for bracing as per drawing No. S-08
c) Pin and channel for support transformer as per drawing No. S-09

3.5 COMPONENTS

a) The components that make up a Pin Cross Arm are as follows:
   i. Angle Iron Cross Arm
      70 mm x 70 mm x 7 mm - 1 No.
   ii. Flat Iron Bracing (40mm x 8mm) - 2 Nos.

b) The Components that make up a Tension Cross Arm are as follows:
   i. Angle Iron Cross Arm
      70 mm x 70 mm x 7 mm - 2 Nos.
   ii. Flat Iron Bracing (40 mm x 8mm) - 4 Nos.

c) Bolts, Nuts and Washers necessary for the Pin and Tension Cross Arm assemblies are not required to be supplied.

3.6 FINISH

Galvanized coating on all components of the cross arm assembly shall be smooth, continuous, uniform and free from flux stains and nodules of spelter.

4.0 QUALITY ASSURANCE

The manufacturer shall pose ISO 9002 Quality Assurance Certification for the plant where the galvanizing work is done. The bidder shall furnish a copy of the ISO Certificate certified as true copy of the original by the manufacturer, along with the offer.

5.0 ADDITIONAL REQUIREMENTS

5.1 MARKING

Manufacturer's identification marks and the letter "MWP" shall be impressed clearly on all components such as cross arms and bracings before galvanizing.

5.2 ROUTINE TEST

The following routine tests shall be carried out on all the cross arms assembly manufactured.

a) Visual inspection
b) Dimensional check
c) Galvanizing

5.3 PLANT FACILITIES

The manufacturer shall have all the equipment such as Shot / Grit blasting, Punching, Cutting, Welding, Bending, Forging and hot dip galvanizing plant necessary for the fabrication of the galvanized steel cross arm assemblies at the place of manufacture.

5.4 MANUFACTURING EXPERIENCE

The manufacturer shall have at least a minimum of five years experience in fabrication of steel structures and shall furnish documentary evidence with the offer in proof of this.

6.0 INFORMATION TO BE SUPPLIED WITH THE OFFER

6.1 FOLLOWING SHALL BE FURNISHED WITH THE OFFER

a) Completed table of guaranteed technical particulars.
b) Full details of manufacturing and plant facilities available at the place of manufacture.
c) Manufacturing experience and list of supplies in the past five years
d) Quality Assurance Certification conforming ISO 9002 for the galvanizing plant.
e) Complete dimensional drawings of:
   i) Pin and tension cross arm assembly
   ii) Bracings
   iii) Support of transformer

6.2 TEST CERTIFICATES

The following test certificates shall be furnished with the offer

a) Mill certificates for the following for Channel iron, Flat iron and Angle iron,
   i) Chemical composition
   ii) Ultimate Tensile strength
   iii) Yield Strength
   iv) Percentage elongation

b) In case of foreign suppliers the full particulars of the pre-shipment inspection institution as specified in Clause 8.3.

Failure to furnish the above particulars and the sample as per clause 7.0 will result in the offer being rejected.

7.0 SAMPLE

One sample (non returnable) of each type of cross arm assembly shall be furnished with the offer. Not required in the present Bidding Documents.

8.0 INSPECTION AND TESTING

8.1 INSPECTION

The selected tendered shall make necessary arrangements for inspection by an Engineer appointed by the MWP and also to carry out acceptance tests in his presence. Routine test report shall be made available for the observation of the inspector.

8.2 ACCEPTANCE / SAMPLE TESTS

USAID/Afghanistan
U.S. Embassy Cafe Compound
Great Massoud Road
Kabul, Afghanistan
Tel: 202.216.6288
http://afghanistan.usaid.gov