POWER GRID BANGLADESH PLC

Bidding Document
for

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Volume 2 of 3 [Substation]

Issued on	**:**	16.09.2025
Invitation for Bids No.	**:**	27.21.0000.101.07.429.25.4270
Contract No.	**:**	POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2
Country	**:**	**Bangladesh**
Employer	**:**	

Power Grid Bangladesh PLC
Grid Bhaban, Avenue-3, Jahurul Islam city,
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BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 1

SCOPE OF WORK

SECTION 1

SCOPE OF WORK

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SECTION 1

SCOPE OF WORK

1.1 DESCRIPTION OF THIS BID

The salient features of the work covered by this Bid and Specification is outlined below, for 230KV, 132 kV and 33kV rated voltage outdoor type Air Insulated Switchgear (AIS) substation plant and civil works.

This Bidding Document is for the design, manufacture, quality assurance, new packing for export, insurance and shipment to site, complete construction and installation, jointing, terminating, bonding, earthing, painting, setting to work, site testing and commissioning, warranty for a period as per conditions of contract for all equipment, including all civil works.

The detailed requirements are listed in Schedule-A (Schedule of Requirements). The brief description of works under this contract is as follows:

1.1.1 Madhabpur 230/132/33kV AIS Substation

The scope of work under this turnkey Bid is design, supply, delivery, installation, testing & commissioning of outdoor type AIS substation of 230KV, 132KV & 33KV switchyard.

i) **230kV Switchyard (Double Busbar scheme)**

- Four 230kV line bays to connect Line in-out of existing 230kV Cumilla (N)-Shahjibazar double circuit overhead line (Cumilla (N) 1 & 2, Shahjibazar 1 & 2);
- Three 230kV transformer bays for HV side of two 230/132/33kV transformer;
- One 230kV bus-coupler bay;
- Three sets of 230/132/33kV, 225/300MVA, three phase auto transformers

ii) 132kV Switchyard (Double Busbar scheme)

- Four 132kV line bays to connect Line in-out of existing 132kV Shahjibazar -Brahmanbaria double circuit overhead line (Shahjibajar 1 & 2 and Brahmanbaria 1 & 2);
- Three 132kV transformer bays for LV side of two 230/132/33kV transformer;
- Two 132kV transformer bays for HV side of two 132/33kV transformer;
- Two sets of 132/33kV, 80/120MVA, three phase transformers
- One 132kV bus-coupler bay;

iii) 33kV Switchyard (Single Busbar scheme)

- Two 33kV transformer bays for LV side of two 132/33kV transformer;
- Two 33kV transformer bays for HV side of two 33/0.4 kV transformer;
- Two sets of 33/0.4kV, 300KVA, three phase auxiliary transformers
- One 33KV bus-Sectionalizer;

1.1.2 Monohardi 230/132/33kV AIS Substation

The scope of work under this turnkey Bid is design, supply, delivery, installation, testing & commissioning of outdoor type AIS substation of 230KV, 132KV & 33KV switchyard

i) **230kV Switchyard (Double Busbar scheme)**

- Four 230kV line bays to connect Line in-out of existing 230kV Sripur -Ashuganj double circuit overhead line (Sripur 1 & 2, Ashuganj 1 & 2);
- Two 230kV transformer bays for HV side of two 230/132/33kV transformer;
- One 230kV bus-coupler bay;
- Two sets of 230/132/33kV, 225/300MVA, three phase auto transformers;

ii) 132kV Switchyard (Double Busbar scheme)

- Two 132kV line bays to connect Bajitpur 132/33KV Sub-station (Bajitpur 1 & 2);
- Two 132kV transformer bays for LV side of two 230/132/33kV transformer;
- Two 132kV transformer bays for HV side of two 132/33kV transformer;
- Two sets of 132/33kV, 80/120MVA, three phase transformers;
- One 132kV bus-coupler bay;

iii) 33kV Switchyard (Single Busbar scheme)

- Two 33kV transformer bays for LV side of two 132/33kV transformer;
- Two 33kV transformer bays for HV side of two 33/0.4 kV transformer;
- Two sets of 33/0.4kV, 300KVA, three phase auxiliary transformers
- One 33KV bus-Sectionalizer;

1.1.3 Extension of Bajitpur 132/33kV AIS Substation

The scope of work under this turnkey Bid is design, supply, delivery, installation, testing & commissioning of outdoor type AIS substation of 132KV switchyard extension with two 132KV Bay. (Monohardi 1 & 2)

i) 132kV Switchyard (Double Busbar scheme)

- Two 132kV line bays to connect Monohardi 132/33KV Sub-station (Monohardi 1 & 2);

The scope of work also includes associated control, protection, fibre optic multiplexer equipment for communication & protection, substation automation, station power facilities, and associated civil works for accommodating protection and control IEDs and associated equipment,

outdoor switchyards, cable trenches, water supply & sewerage, security wall, access road & internal roads, etc.

The "Schedule of Requirements" for equipment, materials and services and the detailed technical specifications of equipment and materials of the Bidding Document shall be read in conjunction with the scope of work described herein. The drawings provided in the Bidding Document are indicative only and hence the entire scope of work is not fully reflected in those drawings.

The Contractor is responsible for ensuring that all and any items of work required for the safe, efficient and satisfactory completion and functioning of the works, are included in the Bid price whether they be described in the specification or not.

1.2 SYSTEM ELECTRICAL PARAMETERS

1.2.1 System Conditions

Equipment supplied under this Contract shall be suitable for the following system conditions.

Nominal system voltage between phases	kV	400	230	132	33
System frequency	Hz	— 50 —			
Rated voltage between phases	kV	420	245	145	36
Lightning Impulse withstand Level	kV p	1550 for Bus PI 1425 for other equipment	1050	650	170
Switching Impulse withstand Level	kV p	1175(Ph-E) for Bus PI 1050(Ph-E) for other equipment		—	—
50Hz withstand 1 minute	kV	650	460	275	70
Symmetrical short-circuit current (1 sec)	kA	63	50	40	31.5

1.2.2 System Earthing

All the power transformers shall be solidly earthed.

1.2.3 Minimum Substation Clearances

Air insulated connections shall have electrical clearances as listed in the following table:-

Nominal system voltage between phases	kV	400	230	132	33
Minimum clearance between live metal and earth	mm	3500	2100	1300	380
Minimum clearance between live	mm	4000	2400	1500	430

metal					
Minimum safety clearance between ground and the nearest point not at earth potential of an insulator	mm	2500	2500	2500	2500
Minimum safety clearance between ground and the nearest live unscreened conductor (BS 7354 'Safety Working Clearance')	mm	6400	4270	3800	2800
Minimum insulator creepage distance (at rated voltage between phases)	mm /kV	25	25	25	25

1.2.4 Low Voltage AC System

Rated service voltage (3 phase, 4 wire 50 Hz)	415 volts
Tolerance on rated voltage	±5%
Switchgear symmetrical breaking capacity	10 kA/6kA/4kA, 3 sec
System earthing	Solid

1.2.5 D.C. System

For d.c. motor driven auxiliaries, relays, tripping, indicating lamps and controls.

Normal battery voltage	110 V nominal
Tolerance on rated voltage	±5%

For telecommunication & future SCADA

Normal battery voltage	48 V nominal
Tolerance on rated voltage	±5%

1.3 CLIMATIC CONDITIONS

All plant and equipment supplied under the Contract shall be entirely suitable for the climatic conditions prevailing at site.

The project area and vicinity is close to sea level and is in a tropical climate. The ambient shade temperature variation is between 4°C and 45°C with periods of high humidity.

Between May and November low lying areas are subject to flooding.

The flooding can be taken advantage of at certain Sites in that the heavy loads may be floated on barges to close proximity to the Sites.

The project area is designated a zone of moderate intensity for earthquakes. The seismic factor is 0.2 g.

Atmospheric pollution is moderate and special insulator design or washing is not required. The area is subject to high winds of typhoon strength.

Maximum ambient shade temperature	45°C
Minimum ambient shade temperature	4°C
Maximum daily average temperature	35°C
Maximum annual average temperature	25°C
Maximum wind velocity	160 Km/h
Minimum wind velocity for line rating purposes	3.2 Km/h
Solar radiation	100 mW/sq.cm
Rainfall	2.5 m/annum
Relative humidity, maximum	00%
Relative humidity, average	80%
Altitude	less than 150 m
Atmospheric Pollution	light
(No ice or snow expected)	
Soil type	alluvial
Soil temperature (at 1.1m)	30°C
Soil thermal resistivity	1.5°Cm/W
Isokeraunic Level (Thunderstorm days/year)	80

The information in this Clause is given solely for the general assistance of Bidders and no responsibility for it will be accepted nor will any claim based on this Clause be considered.

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SECTION 2

ANCILLARY MECHANICAL AND ELECTRICAL APPARATUS

SECTION 2

ANCILLARY MECHANICAL AND ELECTRICAL APPARATUS

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SECTION 2

ANCILLARY MECHANICAL AND ELECTRICAL APPARATUS

2.1 SCOPE

This section of the Technical Specification describes the general requirements for mechanical and electrical designs of all the plant being supplied under the Contract, electrical aspects being covered in the another Section of the Specification. It shall be read in conjunction with the General Conditions, Drawings, the Schedules and other sections of the Technical Specification covering particular aspects of the plant and in the event of conflict between the General and Definite Contract Requirements, then the latter shall take precedence

2.2 REFERENCES

2.2.1 ISO Standards

ISO68-1 General Purpose Screw Threads
ISO261 General Purpose Metric Screw Threads
ISO262 Selected sizes for screws, bolts & nuts
ISO272 Fasteners - hexagon products – widths across flats
ISO885 General purpose bolts and screws - metric series
ISO888 Bolts, screws and studs - nominal lengths, and thread lengths for general purpose bolts
ISO965/1,2,3 General purpose Metric screw threads
ISO4759-1 Tolerances for fasteners
ISO9000 Quality management and quality assurance standards
ISO9001 Quality management systems. Requirements

2.2.2 IEC Standards

60072 Dimensions and output series for rotating electrical machines
60073 Coding of indicating devices and actuators by colours
60079 Electrical apparatus for explosive gas atmospheres
60085 Thermal evaluation and classification of electrical insulation
60137 Bushings for alternating voltages above 1000 V
60168 Tests on indoor and outdoor post insulators of ceramic material
60228 Conductors of insulated cables
60034 Rotating Electrical Machines
60038 IEC Standard Voltages
60044-1 Instrument transformers - Part 1: Current transformers
60044-2 Instrument transformers - Part 2: Inductive voltage transformers
60044-5 Instrument transformers - Part 5: Capacitor voltage transformers
60051 Direct acting indicating analogue electrical measuring instruments and their accessories
60055 Paper insulated metal sheathed cables to 18/30 kV
60059 IEC Standard Current Ratings

60228A First supplement. Guide to dimensional limits of circular conductors
62155 Tests on hollow insulators for use in electrical equipment
60269 Low voltage fuses
60273 Characteristics of indoor & outdoor post insulators above 1000 V
60282 High voltage fuses
60296 Specification for unused mineral insulating oils for transformers & switchgear
60305 Characteristics of string insulator units of the cap & pin type
60332 Tests on electrical cables under fire conditions
60364 Electrical installations of buildings
60383-2 Insulators for overhead lines above 1000 V
60417 Graphical symbols for use on equipment
60423 Conduits for electrical purposes
60433 Characteristics of string insulator units of the long rod type
60437 Radio interference test on high voltage insulators
60439(1-4) Low voltage switchgear and control gear assemblies
60455 Solventless polymersable resinous compounds used for electrical insulation
60502 Extruded solid dielectric insulated power cables from 1 - 30 kV
62052-11 Electricity metering equipment - General requirements
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60529 Degrees of protection provided by enclosures (IP Codes)
60587 Test methods for evaluating resistance to tracking
60614 Conduits for electrical installations - Specification
60621 Electrical installations for outdoor sites under heavy conditions
60644 Specification for high-voltage fuse links for motor circuit applications
60660 Tests on indoor post insulators of organic mats. between 1 - 300 kV
60672 Specification for ceramic & glass insulating mats.
60898 Circuit Breakers for overcurrent protection for households etc.
60947-1 Low-voltage switchgear and controlgear - Part 1: General rules
60947-2 Low-voltage switchgear and controlgear - Part 2: Circuit-breakers
60947-3 Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
60947-5-1 Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and witching elements
60981 Extra heavy duty steel conduits for electrical installations
61035 Specification for conduit fittings for electrical installations
61084 Cable trunking & ducting systems for electrical installations
62271-1 High-voltage switchgear & controlgear - Part 1: Common specifications
62271-100 High-voltage switchgear & controlgear - Part 100: High - voltage alternating-current circuit breakers
62271-102 High-voltage switchgear & controlgear - Part 102: Alternating current disconnectors and earthing switches
62271-105 High-voltage switchgear & controlgear - Part 105: Alternating

current switch-fuse combinations
62271-200 AC metal - enclosed switchgear & control gear for 1 kV and above

2.2.3 British Standards

BS29 Spec for Carbon steel forgings
BS 182 Specification for galvanised line wire for telephone & telegraphic purposes
BS 443 Specification for testing zinc coatings on steel wire
BS499 Welding terms & Symbols
BS709 Method & testing fusion welded joints
BS 729 Specification for hot dip galvanised coatings on iron & steel articles
BS970 Specification for wrought steels for mechanical & allied engineering
BS CP 1014 Tropicalisation
BS 1224 Specification for electroplate coatings of nickel and chromium
BS1710 Specification for identification of pipelines & services
BS 1780 Specification for Bordon tube pressure and vacuum gauges
BS 1858 Specification for bitumen based filling compounds
BS 2011 Environmental Testing
BS 2569 Pt2 Protection of iron & steel against corrosion at elevated temp.
BS 2600 Pt 1 Radiographic examination of fusion welded butt joints in steel
BS 2765 Specification for dimensions of temperature detecting elements
BS 2910 Radiographic examination of fusion welded circumferential butt joints
BS 3858 Specification for sleeves for electric cables & wires
BS3923 Pt1 & Pt2 Methods of examination of fused welds and butt joints.
BS 4211 Specification for ladders for permanent access to chimneys, other high structures, silos and bins
BS4395-1-2 Specification for High Strength Grip Bolts
BS4479 Pts 1-9 Recommendations for coatings.
BS 4592 Pt 1-4 Industrial type flooring, walkways and stair treads
BS4604 Pt 1-2 Spec for high strength friction bolts
BS4670 Spec for alloy steel forgings.
BS 4800 Schedule of Paint Colours for building
BS 4675 Pt2 (ISO 2954) Mechanical vibration of rotating and reciprocating machinery
BS 4872 Pt 1 Fusion welding of steel
BS 5395-3 Code of Practice for the design of industrial type stairs, permanent ladders etc.
BS 5493 Code of practice for protective coating of iron & steel structures against corrosion
BS6072 Method for penetrant flaw detection
BS 6121-1 Specification for metallic cable glands

BS 6121-2	Specification for polymeric cable glands
BS 6121-3	Specification for special corrosion resistant cable glands
BS 6180	Code of Practice for barriers in and about buildings
BS 6231	Specification for PVC insulated cables for switch & control wiring
BS6443	Method of penetrant flaw detection.
BS7079	Preparation of steel substrates before application of paints

2.2.4 BS European Standards

BSEN287 -1&-2	Approval testing of welders for fusion welding
BSEN288-1 thru to.-8	Specification & Approval of welding procedures

2.3 DEFINITION OF TERMS

The definition of terms shall be as set out in the General Conditions of Contract.

2.4 STATUTORY REGULATIONS

The Works and all equipment and materials forming part of this Contract shall comply in all respects with any relevant statutory regulations, by-laws or orders currently in force in Bangladesh.

2.5 DESIGN STANDARDS AND CODES

2.5.1 General Compliance with International Standards and Codes

The Contract Works shall comply with the relevant standards as specified. Provided there is no conflict with the standards, and unless otherwise stated, all parts of the Works shall comply with the relevant international standards and design codes. Where suitable international standards do not exist, internationally accepted national standards (which ensure equivalent or higher quality than specified standard) or other approved standards shall apply.

2.5.2 Standards Named in Specification

Although the Works shall generally comply with international standards, any instruction in this Specification that a particular aspect of the Works shall comply with a named code or standard shall take precedence, and that particular aspect of the Works shall comply with the named code or standard.

2.5.3 Hierarchy of Standards

In the event of any conflict in standards, the hierarchy of standards shall be as follows, with the standards occurring first in the list taking precedence over any standards later in the list:

i) Statutory regulations of Bangladesh
ii) Standards named in the Specification
iii) International Standards
iv) Other standards approved by the Engineer

Where equipment is specified to a particular standard, the Bidder may supply equipment of an equivalent standard, if approved by the Engineer.

2.5.4 Substitution of Standards and Design Codes

The Bidder may offer Works which comply with international standards, or internationally-recognized national codes or standards, which differ from those specified. However the Bidder may offer Works which comply with the different standards or codes only if, when requested by the Engineer, he is able to demonstrate to the Engineer's satisfaction that the Works offered are equal or superior to that which would have resulted had the specified code or standard been used. This substitution of codes or standards for those specified will only be acceptable if the manufacturing organization in question has extensive experience with the alternative code or standard offered.

Any Bidder offering Contract Works or part of those Works to standards and codes which differ from those specified shall declare the fact to the Engineer. If requested to do so by the Engineer, the Bidder shall supply to the Engineer, at his own cost, two copies in English of the relevant code or standard which he proposes to substitute for that specified.

2.6 ERECTION MARKS

All members comprising multipart assemblies, e.g., steel frameworks, piping installations, etc., shall be marked with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks, if impressed, must be completed before painting or galvanising, shall be clearly readable afterwards.

Colour banding to an approved code shall be employed to identify members of similar shape or type but of differing strengths or grades.

2.7 CLEANING AND PAINTING

2.7.1 General

Following award of the Contract, the Bidder shall submit the name of the proposed paint supplier and applicator, together with a quality assurance programme, for approval. All paints for the outdoor equipment on the

Contract shall be provided by one manufacturer and preferably shall be manufactured in one country to ensure compatibility. All painting of outdoor equipment shall be carried out strictly in accordance with the paint system manufacturer's recommendations and the application shall be checked and approved, in writing, by an authorized representative of the paint manufacturer.

The painting of the plant shall be carried out in accordance with the appropriate schedule later in this Section. The work is generally covered by the Schedules but where particular items are not referred to specifically, they shall be treated in a manner similar to other comparable items as agreed with the Engineer.

The Bidder shall ensure that precautions are taken in packing and crating, to avoid damage to the protective treatment during transportation to the site. Any damage to paintwork which occurs during transport shall be made good at Site.

The schedules indicate standards of surface preparation and painting which are intended to give a minimum life of 10 years in a severe environment, with need for only minor remedial work in that period.

Steel sections and plate shall be free from surface flaws and laminations prior to blast cleaning and shall not be in worse condition than ISO 8501-1.

Where paint coatings are proposed for the protection of surfaces of equipment exposed to corrosive conditions, such as plant items exposed to brine or sea water, or immersion in liquids or wet gases, the coatings shall be formulated to be suitably corrosion resistant and shall be high voltage spark tested at works and at Site prior to commissioning. The test procedure shall be based on the use of a high voltage direct current. The voltage used shall be 75% of the breakdown voltage of the coating. This breakdown voltage shall first be separately determined using test plates coated with the specified coating formulation and thickness. The coating on the test plate shall also be micro-sectioned by the applicator to show that it is free from vacuoles and other defects likely to invalidate the test procedure.

If the defects revealed by the above test procedure do not exceed one per 5 m^2 of coating surface, the coating need not be re-tested after the defects have been repaired. If the defects exceed one per 5 m^2 of coating surface, the repairs shall be re-tested after any curing is complete, and this procedure shall be repeated until the defects are less than one per 5 m^2 of coating surface. After repair of these defects, the equipment can be placed in service without further testing.

All coatings proposed for the internal protection of domestic water storage tanks and desalination plants shall be certified by an approved independent Authority as suitable for use in potable water installations and shall meet the non-tainting requirements of BS 3416.

The Engineer will consider alternative paint schemes to meet the requirements of fabrication using modern automated materials handling systems, provided that the Bidder is able to demonstrate that they offer the same standards of surface protection and service life as those intended by the Schedules.

All paints shall be applied by brush or spray in accordance with the schedule, except for priming coats for steel floors, galleries and stairways where dipping will be permitted.

Where paint is to be applied by spray, the applicator shall demonstrate that the spray technique employed does not produce paint films containing vacuoles.

All planished and bright parts shall be coated with grease, oil or other approved rust preventative before dispatch and during erection and this coating shall be cleaned off and the parts polished before being handed over.

Where lapped or butted joints from part of an assembly which is assembled or part assembled prior to final painting, the jointed surfaces shall be cleaned free from all scales, loose rust, dirt and grease and given one brush applied coat of zinc phosphate primer before assembly.

Paint shall not be applied to surfaces which are superficially or structurally damp and condensation must be absent before the application of each coat. Painting shall not be carried out under adverse weather conditions, such as low temperature (below 4˚C) or above 90% relative humidity or during rain or fog, or when the surfaces are less than 3˚C above dew point, except to the approval of the Engineer or his duly appointed representative.

Priming coats of paint shall not be applied until the surfaces have been inspected and preparatory work has been approved by the Engineer or his duly appointed representative.

No consecutive coats of paints, except in the case of white, shall be of the same shade. Thinners shall not be used except with the written agreement of the Engineer.

On sheltered or unventilated horizontal surfaces on which dew may linger, more protection will be needed and to achieve this an additional top coat of paint shall be applied.

The schedules differentiate between "Treatment at Maker's Works" and "Treatment at Site after Completion of Erection" but the locations at which different stages of the treatments are carried out may be modified, always providing that each change is specifically agreed to by the Engineer and the painting is finished or made good at Site to the Engineer's satisfaction.

The schedules also refer to "Indoor" and "Outdoor" locations. In this context the interiors of all buildings without air conditioning, heating or forced ventilation shall be treated as "Outdoor".

All paint film thicknesses given are minima and refer to the dry film condition. All thicknesses shall be determined by the correct use of approved commercial paint film thickness measuring meters.

All outdoor painting shall be checked prior to issue of the final certificate and no visible corrosion or spotting shall be present. Slight loss of gloss may acceptable. In the event of visible corrosion being present, the Employer will retain the right to withhold such an amount from the Bidder as may be necessary to repaint the entire exterior part of the works.

The painting requirements shall be interpreted in accordance with the requirements and recommendations of the Standards and Codes of Practice referred to and the paint manufacturer's special instructions where applicable, colours being in accordance with BS 1710 and BS 4800, or equivalent material standards.

2.7.2 Schedules of Finishes

2.7.2.1 Schedules for Indoor Surfaces

2.7.2.1.1 General

(a) Structural and supporting steelwork, plant items above ground, tank external surfaces. All not above 95˚C (or 65˚C for chlorinated rubber finishes).

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Blast clean to BS 7079 2nd quality (SA 2.5) profile amplitude 40-75 microns. Then apply within 4 hours one coat (13 microns) weldable holding primer for 12 months xmatch protection. After fabrication is complete dress all welds, thoroughly clean to remove corrosion products, oil, grease and dirt and apply one coat (50 microns) of two pack epoxy zinc phosphate primer followed by two coats two pack epoxy micaceous iron oxide (250 microns total).	Thoroughly clean to remove oil, grease and dirt. Paint coats to be touched up where necessary. Then apply one tie coat to finish (30 microns) and one coat alkyd gloss (25 microns)

(b) Steel floors, chequer plates, galleries, stairways, treads, kick stops.

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Galvanize to BS 729	Thoroughly clean to remove oil, grease and dirt. Where galvanizing is damagedwire brush to BS 7079 3rd quality (SA2) and apply 1 coat zinc rich epoxy primer (50 microns). Then apply: 1st coat etch primer 2nd coat epoxy zinc chromate 3rd coat 2 pack epoxy micaceous iron oxide (50 microns). On galleries and stairways top surfaces apply 4th coat non skid epoxy deck paint (30 microns).

(c) Galvanized iron and steel requiring paint finish

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Galvanize to BS 729	Thoroughly clean to remove oil, grease and dirt. Then apply:- 1st coat of etch primer 2nd coat of zinc chromate primer (30 microns) 3rd coat alkyd undercoat (30 microns) 4th coat alkyd gloss (25 microns).

(d) Stainless steel, aluminium alloys and non ferrous alloys requiring paint finish.

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Not Applicable	Thoroughly clean to remove oil, grease and dirt. Then apply:- 1st coat alkyd undercoat (30 microns) 2nd coat alkyd gloss (25 microns).

(e) Bitumen dipped items

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Bitumen dipped.	Thoroughly clean to remove oil, grease and dirt. Then apply:- 1st coat general purpose aluminium paint (18 microns) 2nd coat alkyd undercoat (30 microns) 3rd coat alkyd gloss (25 microns).

2.7.2.1.2 Battery Rooms (open top batteries), Chlorination Plant Rooms, Electrolytic Cell Rooms

(a) Steelwork

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Blast clean to 2nd quality BS 7079(SA2.5) profile amplitude 40-75 microns and apply: -	Thoroughly clean to remove oil, grease and dirt. Priming coat to be touched up where necessary. Then apply:- 1st coat chlorinated rubber primer to manufacturer's instructions 2nd coat high build chlorinated rubber (80 microns) 3rd coat high build chlorinated rubber (80 microns).

2.7.2.1.3 Bright Parts

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Coat with a mixture of oil, grease or approved proprietary inhibitor.	Clean and polish

2.7.2.1.4 Instrument Panels, Relay Panels, Control Panels, 400V A.C. Boards, 110V D.C. Boards, Telemetry Marshalling Kiosks, Lighting and Small Power Distribution Boxes, Battery Charger Cubicles, Metal Clad Switchgear

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Acid pickle or blast clean to 1st quality BS 7079. Then apply:- 1st coat zinc chromate primer (30 microns) Stop and fill. Then apply:- 2nd coat alkyd undercoat (30 microns) Rub down with fine abrasive paper 3rd coat alkyd undercoat (30 microns) Rub down with fine abrasive paper Then apply: - 4th coat alkyd matt (25 microns) 5th coat alkyd matt (25 microns) 6th coat alkyd matt (25 microns) Total film thickness (125 microns).	Touch up if necessary and burnish

2.7.2.2 Schedules for Outdoor Surfaces

2.7.2.2.1 General

(a) Structural and supporting steelwork, plant items above ground, tank external surfaces. All not above 95˚C (or 65˚C for chlorinated rubber finishes).

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Blast clean to BS 7079 2nd quality (SA2.5) profile amplitude 40-75 microns. Then apply within 4 hours one coat (13 microns) weldable holding primer for 6 months protection or (25 microns) weldable holding primer for 12 months protection. After the protection period, thoroughly clean to remove oil, grease and dirt and apply one coat (50 microns) of two pack epoxy zinc phosphate primer followed by two coats two pack epoxy micaceous iron oxide (250 microns total).	Thoroughly clean to remove oil, grease and dirt. Paint coats to be touched up where necessary. Then apply one tie coat to match finish (30 microns) and one coat alkyd gloss (25 microns)

(b) Steel floors, chequer plates, galleries, stairways, treads, kick stops

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Galvanized to BS 729	Thoroughly clean to remove oil, grease and dirt. Where galvanizing is damaged wire brush to BS 7079 3rd quality (SA2) and apply I coat zinc rich epoxy primer (50 microns) Then apply: 1st coat epoxy etch primer 2nd coat epoxy zinc chromate (30microns) 3rd coat two pack epoxy micaceous iron oxide (100 microns) On galleries and stairways top surfaces apply 4th coat non skid epoxy deck paint (30 microns).

(c) Galvanized iron and steel requiring paint finish

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Galvanized to BS 729	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat etch primer 2nd coat zinc chromate primer (30microns) 3rd coat alkyd undercoat (30 microns) 4th coat alkyd gloss (25 microns).

(d) Stainless steel, aluminium alloys and non ferrous alloys requiring paint finish

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Not applicable.	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat alkyd undercoat (30 microns) 2nd coat alkyd gloss (25 microns).

(e) Bitumen dipped items

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Bitumen dipped.	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat general purpose aluminium paint (18 microns) 2nd coat alkyd undercoat (30 microns) 3rd coat alkyd gloss (25 microns)

2.7.2.2.2 Bright Parts

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Coat with a mixture of oil, grease or approved proprietary inhibitor.	Clean and polish

2.7.2.2.3 Instrument Panels, Control Panels, Marshalling Kiosks, Lighting and Small Power Distribution Boxes and Junction Boxes etc.

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
Blast clean, prime, undercoat and paint in accordance with the painting schedule for structural and supporting steelwork, with finish coat of paint applied at manufacturer's works	Clean and touch up as necessary

2.7.2.2.4 Water and Oil Storage Tanks - Internal Surfaces

The epoxy paint formulation shall be to the approval of the Engineer. The finished coating shall be capable of being tested with a high voltages spark tester for absence of pinholes and porosity.

For oil storage tanks, solvent-free epoxy paint formulation shall be used.

TREATMENT AT MAKERS WORKS	TREATMENT AT SITE AFTER COMPLETION OF ERECTION
For tanks delivered to site in plate sections, the plates shall be blast cleaned to BS 7079 1st quality (SA3) profile amplitude 40-75 microns and then within 4 hours coat with a weldable holding primer dry film thickness 25 microns	Welded Construction at Site. After erection all welds shall be dressed to remove rough edges and burrs and all sharp edges shall be radiused 3 mm Prior to painting, all surfaces shall be sweep blast cleaned to a sound surface free from rust and debris. Then apply within 4 hours: 1st coat Isocyanate or amine cured epoxy primer 25 microns 2nd coat Isocyanate or amine cured high build epoxy (125 microns) 3rd coat Isocyanate or amine cured high build epoxy (125 microns).
Sectional Construction Prior to assembly all component items to be blast cleaned to BS 7079 Ist quality (SA3) profile amplitude 40-75 microns. Then apply:- Ist coat Isocyanate or amine cured epoxy primer (25 microns). After assembly clean all surfaces free from rust, grease and dirt. Priming coat to be touched up as necessary. Then apply: 2nd coat Isocyanate or amine cured high build epoxy (125 microns) 3rd coat Isocyanate or amine cured high build epoxy (125 microns).	Sectional Construction Touch up damaged areas as necessary.

2.7.2.3 Radiators

Radiators shall be thoroughly cleaned and treated externally by phosphating or other approved rust inhibiting process and given, preferably by flood painting, the same number and type of coats specified in above. Radiators which are hot dip galvanised to BS.729, Part 1, shall be artificially weathered and given one coat of zinc chromate primer followed by the same number and type of paint coatings specified in Clause. Radiators shall be painted with Munsell colour No. 5Y-7/1.

2.8 RATING PLATES, NAMEPLATES AND LABELS

2.8.1 General

The Bidder shall supply and install all labels, name, rating, instruction and warning plates necessary for the identification and safe operation of the Works. Samples shall be submitted for the approval of the Engineer.

Nameplates or labels shall be of non-hygroscopic, non-deteriorating and non-warping material with engraved lettering of a contrasting colour or, in the case of indoor circuit-breakers, starters, etc, white plastic material with black lettering engraved thereon. Items of Plant such as valves, mounted outdoors or subject to harsh operating conditions, shall be provided with engraved chromium plated brass or stainless steel nameplates or labels with engraving filled with black enamel.

All the above labels and plates shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self tapping screws or other approved means. The use of adhesives will not be permitted.

Individual plant items and all relevant areas within the contract works where a danger to personnel exists shall be provided with plentiful, prominent and clear warning notices.

These warning notices shall draw attention to the danger or risk with words in the language specified which attract attention and summarise the type of risk or danger. The notices shall also carry a large symbol which graphically depicts the type of risk.

All equipment within panels and desks shall be individually identified.

Items of Plant, such as valves, which are subject to handling, shall be provided with nameplates with permanent inscriptions thereon.

2.8.2 Rating Plates

Each main and auxiliary item of Plant shall have attached to it in a conspicuous position, a rating plate upon which shall be engraved all appropriate technical data and any identifying name, type or serial number, and the requirements of the Standard specific to the item of plant. In addition the Engineer may require to be included details of the loading conditions under which the item of Plant in question has been designed to operate, such as the short-time rating of switchgear.

2.8.3 Circuit Labels

Each main item of Plant shall be provided with an identification plate. The inscriptions shall be approved by the Engineer.

In addition the device number allocated by the Engineer to each item of Plant shall be displayed in text height 30mm on all operating mechanisms and 60mm or larger in height on principal items of Plant, e.g. busbars, transformers etc. The same device number shall be displayed on control cubicles in text height 10mm or larger as may be required by the Engineer.

2.8.4 Pipe Service Identification

A colour banding scheme shall be used to identify pipework included within this Contract. The colours employed shall be in accordance with the painting specification herein.

Colour bands shall be painted on each side of all valves and items of equipment in the piping systems. The use of adhesive-backed colour bands is not permitted.

Valve labels shall be circular and fitted under the handwheel captive nut. For check valves and small valves the Bidder may provide rectangular labels fitted to the valve or secured close by the valve.

The inscription or "name" on each valve label shall summarise the duty of the valve, and the number shown on each valve label shall be the number in the unified plant valve numbering scheme.

Where the direction of flow through a valve or other device is an important requirement for correct functioning, the body of the valve or device shall be legibly marked with a cast on or a properly secured arrow, showing the direction of flow.

Pipework shall be provided with plentiful large painted arrows or other secure and durable arrow markings to allow the flows of fluids around the plant to be readily understood.

2.9 ENVIRONMENTAL PROTECTION & TROPICALISATION

2.9.1 General

All equipment shall be designed to operate in the environmental conditions specified. Outdoor equipment shall be designed so that water cannot collect at any point. The undersides of all tanks shall be ventilated in an approved manner to prevent corrosion.

Where applicable, equipment should tolerate the effects of freezing and air pollution.

Where personnel have to be in attendance frequently, or maintenance has to be regularly carried out, permanent means weather protection or sunshades shall be provided.

Where the performance, reliability or life of the plant would be adversely affected by solar radiation, including the effects of prolonged exposure to ultra violet light, suitable sunshades shall be provided. Such sunshades shall be constructed from materials that are able to withstand the effects of the ambient conditions on site without suffering any deterioration in material strength or effectiveness.

Sunshades need not be provided on outdoor plant or equipment provided the manufacturer can satisfy the Engineer that the materials employed will not be adversely affected or the temperature rise due to internal heat generation plus that due to solar radiation will not exceed the equipment design temperature. However equipment requiring manual operation shall be provided with sunshades to ensure that surface temperatures will not exceed 50□C.

Sunshades shall protect plant and personnel when the sun is more than 45□C above the horizon. They shall not impede the operation or maintenance of the plant or the movement of ventilating air and shall include adequate artificial light as necessary.

Facilities such as lighting, lifting beams and rainwater drainage shall be provided wherever necessary to the approval of the Engineer as an integral part of the sunshade structure.

2.9.2 Tropicalisation

In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which equipment shall work, and good proven practices shall be followed unless otherwise approved by the Engineer. Some relaxation of the following provisions may be permitted where equipment is hermetically sealed but it is preferred that tropical grade materials should be used wherever possible:

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

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

Rubbers: Neoprene and similar synthetic compounds, not subject to

deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc.

2.10 PLATFORMS, STAIRWAYS, LADDERS AND HAND-RAILING

2.10.1 General

The Bidder shall provide all platforms, galleries, stairways and ladders necessary to give access to the various sections of the plant being supplied under this Contract. They shall provide adequate means of access for all operation, inspection and overhaul purposes and shall be of sufficient strength to support workmen, tools and portions of plant which may be placed on them during overhaul and inspection periods.

Galleries, platforms and stairways shall be designed generally for a load of 7.5kN/m^2 but where loads in excess of this are likely to be imposed during operation or maintenance, the Bidder shall make due allowance for the increased loads in the design. Particular care shall be given to their rigidity. All the necessary supports from the floors, buildings and foundations shall be supplied under this Contract.

Galleries and platforms around plant subject to significant expansion shall be designed to allow for such expansion and to provide safe and adequate access for both hot and cold conditions.

Platforms and galleries shall have a minimum width of 850 mm clear passageway and shall be enclosed by hand-railing on both sides. In cases where there is a space not exceeding 200 mm on one side of a passageway hand-railing need be supplied for one side only but an edging strip shall be provided on the side without handrail. The minimum headroom on platforms and galleries shall be 2100 mm.

Ladders will only be permitted where stairways are impractical and access is required for maintenance.

All platforms, stairways, ladders and other accessways, shall comply with the requirements of BS 5395 Part 3, unless otherwise stated.

As far as practical the flooring, stair treads and hand-rails shall conform to a uniform pattern throughout the whole of the Contract Works.

2.10.2 Flooring

The flooring of all platforms, galleries and staircase treads shall consist of an approved type of galvanised mild steel open grid flooring except in those cases where chequer plate is specified.

Toe plates extending to a height of not less than 100 mm above the platform or gallery level and of a thickness of not less than 6 mm shall be supplied. Any opening which it is necessary to cut in the open grid flooring

or chequer plate shall be finished off with an edging strip similar to that on the floor panels.

The open grid flooring and stair treads shall be from an approved manufacturer and generally in accordance with BS 4592.

The pattem of open grid flooring and chequer plate shall be uniform and laid with the pattern in one direction.

Open grid floor panels shall be not less than 25 mm in depth and shall be fitted neatly between kerbs and clamped with nuts and bolts in such a manner as to permit ready removal or replacement. The design of the clamps shall be to approval and only minimal protrusion above the floor level will be permitted.

Where chequer plate is supplied it shall be galvanised mild steel to an approved design. No chequer plate shall be less than 10 mm thick and all plates shall be secured to the supporting steel by galvanised countersunk screws of not less than 10 mm nominal size.

2.10.3 Hand-railing and Protective Barriers

Hand-railing and protective barriers shall be provided wherever necessary to protect operation or maintenance personnel from hazards, and shall comply with BS 6180.

Double hand-railing shall be provided unless otherwise specified. Each length shall be joined by internal ferrules and all joints shall be neatly finished by the removal of all burrs. The top rail shall be not less than 30 mm diameter and mounted at a height of not less than 1100 mm from the gallery or platform level. The intermediate rail shall be not less than 25 mm diameter and mounted at a height of not less than 535 mm from the gallery or platform level. Hand-rails for stairways shall have the top rail at a height of not less than 900 mm and lower rail at not less than 420 mm above the stairway pitch line.

Tubular or solid forged stanchions shall be provided, spaced at a maximum distance of 1750 mm, and to which hand-railing shall be firmly attached.

The stanchions shall be firmly and directly attached to the body of the platform, gallery, stairway or ladder steelwork by bolting, and when erected shall be vertical. They shall not be attached to toe-rails.

In designing hand-railing and its supporting stanchions particular attention shall be paid to the provisions of BS 6180 relating to design loads and to permissible deflections and flexibility.

2.10.4 Stairways

Where specified, main stairways shall have a minimum stair tread width of 1100 mm; other stairways shall have a minimum width of 750 mm. Wherever possible the angle of slope of stairways shall be standardized. Angles exceeding 42˚ to the horizontal shall not be used.

No flight of stairs shall have more than 16 risers. Where a stairway requires more than 16 risers, each flight shall have an approximately equal number of risers and shall be separated by a landing. Risings shall be between 190 mm and 210 mm, and goings shall be between 220 mm and 250 mm in width. Minimum headroom shall be 2.3 m.

2.10.5 Fixed Access Ladders

Ladders shall comply with BS 4211. The minimum width of ladders shall be 500 mm and inclination shall be not less than 70˚, and not more than 80˚ to the horizontal.

2.11 NUTS, BOLTS, STUDS AND WASHERS

The threads and other details of fasteners shall comply with the relevant ISO Standards for metric series fasteners.

Nuts and bolts for pressure parts shall be of the best quality steel.

Nuts, bolts, studs and washers shall be of materials most suitable for the service operating conditions and designed to ensure the stresses arising in normal operation shall not exceed those necessary to ensure that the specified plant life is achieved.

Nuts and bolts for incorporation in the plant are preferably to conform to ISO Metric Coarse to ISO 272. Other sizes or threads are permitted for threaded parts not to be disturbed in normal use or maintenance. Where the Contract includes nuts and bolts of different standards, then the tools to be provided in accordance with this Specification shall include spanners, taps, and dies for these nuts and bolts.

Fitted bolts shall be a driving fit in the reamed holes they occupy, shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site.

Stud holes in those parts of the plant which are subjected to heat in use shall be adequately vented.

The threaded portion of any bolt or stud shall not protrude more than 1.5 threads above the surface of its mating nut.

Where practicable the use of slotted head screws shall be avoided in machinery component assemblies, hexagon socketed screws being

preferred.

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

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

2.12 FORGINGS

The Bidder shall supply a list of all important forgings and draw up material specifications for each one. Copies of this list and specifications shall be supplied to the Engineer for his use. In each case the quality and inspection requirements shall be clearly stated.

Wherever possible steel forgings shall be in accordance with the requirements of BS Standards 29, 970 or 4670, the equivalent ISO Standards or agreed national standards.

Test blocks from which mechanical test pieces will be machined shall be cut from forgings at positions to be agreed by the Engineer. On large and important forgings several test pieces shall be taken from radial and longitudinal directions.

Forgings shall be free from cracks externally or internally, extensive non-metallic inclusions and surface defects. The Bidder shall carry out non-destructive testing of forgings during machining to verify that no unacceptable defects are present.

Repairs by welding or other means shall not be undertaken on forgings at any stage of the production cycle.

Each forging shall be suitably branded with an identification number which shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates relative to the forging.

2.13 CASTINGS

2.13.1 General

Test pieces shall be provided from medium and large castings for all necessary material and chemical tests which are to be witnessed by the Engineer. If required by the Engineer any castings for rotating or highly stressed parts are to be subjected to non-destructive testing by approved methods, including radiographic and ultrasonic, the cost of which shall be borne by the Bidder.

All castings shall be homogeneous and free of shrinkage, pipes, undersizing, porosity or voids. "Bum-in" repairs shall not be acceptable and no welding, filling, interlocking or plugging of defective parts shall be done without the Engineer's approval in writing. All repairs shall be subjected to non-destructive examination (ultrasonics, X-rays, gamma-rays) after heat treatment. Welding repairs to castings that will be in contact with corrosive liquids, such as seawater or brine, will only be permitted under special circumstances.

2.13.2 Steel Castings

The Bidder shall prepare material purchasing specifications for all important castings. Each document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the specifications shall be issued to the Engineer for his use.

Castings may be repaired by welding providing the approval of the Engineer is first obtained. The Bidder shall submit drawings, sketches or photographs showing the location and principal dimensions of the defect together with the proposed weld repair procedure. The maximum size of defect for which weld repair will be permitted is:-

Maximum length of defect - 20 mm
Maximum width of defect - 10 mm
Maximum depth of defect - no greater than 10% of the wall thickness

Only welders who have passed an appropriate qualification test shall be employed on the repair of castings. All repairs shall be carried out by the metal arc process.

Ultrasonic inspection shall be applied to all important castings to locate the extent of sub-surface defects and to check the wall thickness.

All castings shall be identified by stamped or cast-on reference marks, which shall be entered on all relevant documents and test certificates.

The Engineer may require that certain castings be examined using radiographic techniques. The Bidder shall include for this eventuality and shall comply with the Engineer's instructions when issued.

2.13.3 Iron Castings

Cast iron shall not be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 200˚C, unless specifically approved by the Engineer. Nor shall it be used for chambers of oil filled apparatus.

Weldable grades of iron castings may be repaired by welding provided the approval of the Engineer is first obtained. The Bidder shall submit full details of the proposed weld repair procedure and weld procedure qualification test prior to making any weld repairs. The maximum size of defect for which weld repair will be permitted is:-

Maximum length of defect	-	20 mm
Maximum width of defect	-	10 mm
Maximum depth of defect	-	no greater than 10% of the wall thickness.

Test blocks shall be integrally cast on all medium and large castings.

The Engineer may require that certain castings be checked using radiographic techniques. The Bidder shall include for this eventuality and shall comply with the Engineer's instructions when issued.

2.13.4 Aluminium Bronze Castings

The Bidder shall prepare material purchasing specifications for all important castings. Each document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the specifications shall be issued to the Engineer for his use.

The inspection and quality requirements shall include an analysis of each cast, mechanical testing of test pieces from each cast, pressure testing, penetrant flaw detection and radiographic examination of selected critical areas.

Weldable grades of aluminium bronze may be repaired by welding, provided the written approval of the Engineer is first obtained. The Bidder shall submit full details of the proposed weld repair procedure and weld procedure qualification test prior to making any weld repairs. The maximum size of defect for which weld repair will be permitted is:-

Maximum length of defect	-	20 mm
Maximum width of defect	-	10 mm
Maximum depth of defect	-	no greater than 10% of the wall thickness

On completion of repairs, welded areas shall be ground smooth and carefully blended into the parent material. The repaired areas shall be examined for defects using penetrant flaw detection and radiography. Crack-like linear defects shall not be permitted.

2.14 GENERAL WELDING REQUIREMENTS

2.14.1 General

All welding shall conform to the relevant British Standards, or other British

or National Standard Specification as agreed by the Engineer.

Where there is a conflict between Codes and/or Standards the Engineer's decision will prevail.

2.14.2 General Fabrication

The Engineer shall be notified at least two days prior to commencement of any assembly or fabrication work on site.

The C02 and flux-cored welding process will not be acceptable for site welding.

2.14.3 Weld Procedure Documents

Complete and fully detailed weld procedure documents shall be kept by the Bidder and these shall be made available to the Engineer on request.

Prior to commencement of welding the Bidder shall submit to the Engineer for approval the welding procedures to be used in the fabrication of the relevant sections of work.

The weld procedure documents shall be fully detailed and each shall indicate clearly which item it is intended to cover. The procedures shall be in accordance with the requirements of BS 499 Part 1, Appendices A-G.

2.14.4 Weld Procedure Qualification Tests

Weld procedure qualification tests shall be carried out in accordance with the requirements of BS EN 288, or agreed National Standard for the item of Plant under consideration.

Provided that the Bidder confirms that the basic parameters of the procedure have not been changed since approval, the results of weld procedure qualification tests previously carried out under the supervision of an internationally recognised inspecting authority may be accepted by the Engineer.

The Bidder shall inform the Engineer of any proposed changes to the welding procedures before such changes are implemented. If in the opinion of the Engineer a further qualification test is required as a result of such changes, then the Bidder shall perform the required test without additional charge.

The results of all tests shall be made available, for examination by the Engineer, if required.

2.14.5 Welder's Qualification Tests

All welders and welding operators shall be qualified for the work and shall hold current welders' qualification certificates in accordance with BS EN 287, BS 4872 or agreed National Standard for the work.

All welders' tests shall be witnessed and/or approved by the Engineer before the welder or operator is permitted to work. The decision of the Engineer regarding the acceptability of any test or existing qualification tests, shall be final.

Records showing the date and results of the qualification tests performed by each welder and weld operator, together with the identification number assigned to him, shall at all times be available for scrutiny by the Engineer.

2.14.6 Storage of Welding Consumables

Welding consumables shall be stored in a manner that will protect them from all forms of deterioration prior to use and shall be properly identified.

Gas cylinders for use with burning or welding equipment shall be marked in accordance with the requirements of BS 349 or IS0448. Site storage procedures for gas cylinders will require the approval of the Engineer.

2.14.7 Welding Equipment

Any welding equipment which, in the opinion of the Engineer, is unsuitable or unsatisfactory for the purpose for which it is being used, shall be replaced by the Bidder.

2.14.8 Visual Weld Inspection

Each weld shall be subjected to a stringent visual inspection and shall be free from undercut, excessive spatter, craters, cracks, porosity and other surface imperfections. Welds shall be of regular contour, even weld ripple and indicative of good workmanship.

Fillet welds shall be checked for dimensional tolerance and form using a fillet weld gauge. Fillet welds should be slightly concave in form and each leg of the weld shall have equal length.

2.14.9 Internal Examination

The internal root bead of tube butt welds shall be examined by intrascope or other suitable optical device.

2.14.10 Non-destructive Examination

All non-destructive examinations shall be supervised by a fully qualified and experienced specialist appointed by the Bidder. Individual operators in each of the respective techniques shall be qualified and trained in the respective subject and shall have reached a standard comparable with the Certification Scheme of Weldment Inspection Personnel in the United Kingdom.

Testing shall be in accordance with the requirements of BS 709 "Methods of Testing Fusion Welded Joints and Weld Metal in Steel" or an agreed National Standard.

2.14.11 Ultrasonic Examination

Ultrasonic examination of welds shall be carried out in accordance with BS 3923 Part 1 Part 2 and any other relevant British Standards or agreed National Standards.

2.14.12 Magnetic Crack Detection

Magnetic crack detection shall be carried out in accordance with BS 6072 or an agreed National Standard.

2.14.13 Dye Penetrant Tests

Dye penetrant tests shall be in accordance with BS 6443 or any other relevant British or agreed National Standards.

2.14.14 Quality Requirements for Welds

All welds subjected to non-destructive tests shall be entirely free from cracks or crack like defects, lack of root fusion, lack of sidewall fusion, root bum through, or tailed pores. The standard for porosity and slag inclusions will be as indicated in the agreed standards for design and welding.

2.14.15 Weld Repairs

The Engineer's approval shall be obtained prior to commencement of any repair or rectification work.

Weld repairs shall be made to the same procedure as for the original weld. All tests shall be repeated after the repair has been completed and reports on radiographic and ultrasonic tests shall be marked to indicate that the report refers to a repaired weld.

2.14.16 Mandatory Inspections

All transition welds between dissimilar materials, such as high alloy steels

to carbon steel, or austenitic steels or non ferrous materials to steels, shall be subjected to 100% ultrasonic examination or crack detection wherever practicable. In addition, all butt welds between dissimilar materials shall be subjected to 100% radiographic examination.

All welds in ferritic alloy steels, e.g. having a carbon equivalent value in excess of 0.40%, and high yield-strength steels, e.g. having a yield strength greater than 300 MPa, shall be subjected to 100% ultrasonic examination and crack detection wherever possible. In addition, all butt welds in these materials shall be subjected to 100% radiographic examination.

A minimum of 10% of all butt welds on all classifications of work shall be radiographically examined, unless otherwise agreed with the Engineer.

2.15 GALVANISED WORK

All materials to be galvanised shall be of the full dimensions shown or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process commences.

All galvanising shall be done by the hot dip process with spelter, not less than 98% of which must be pure zinc and in accordance with BS 729 or BS 443 as applicable. No alternative process shall be used without the approval of the Engineer. Bolts shall be completely galvanised including the threads, but the threads of nuts shall be left uncoated and shall be oiled.

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible.

Galvanised wire shall comply with the requirements of BS 182 and the thickness of the coating and testing thereof shall comply with BS 443. Nuts and bolts and small components shall be tested in accordance with BS 729. The Engineer may select for test as many components to be weighed after pickling and before and after galvanising as he may think fit.
Galvanised steel shall be treated after galvanising with Sodium Dichromate solution or Pretan W20 to prevent formation of white storagstan. In addition, plastic or other non-metallic nonhygroscopic spacers shall be used between packed members to facilitate ventilation of the zinc surface during shipping.

All galvanised parts shall be protected from injury to the zinc coating due to abrasion during periods of transit, storage and erection. If, in the opinion of the Engineer, the extent of the damage found on Site to a galvanised part appears to be capable of repair the Bidder may, after receiving such agreement, attempt to effect a repair by approved methods. The agreement to attempt the repair shall not bind the Engineer to accept the repaired part when this is re-offered for inspection.

Should an emergency arise on Site necessitating drilling, cutting or any other process likely to damage the protective zinc surface, this will be

permitted only in extreme circumstances and with the Engineer's express authority. In such a case, the bared metal will be coated with an approved zinc rich paint of not less than 92 percent zinc content.

2.16 CHROMIUM PLATING

The chromium plating of those components of the Plant where specified and where offered by the Bidder shall comply with the requirements of BS 1224.

2.17 PUMPS

Pumps should be of the centrifugal type unless strong technical or economic reasons dictate that a positive displacement pump, either rotary or reciprocating, is more appropriate.

Preventive and routine maintenance time should be minimised by the selection of appropriate designs of pump, preferably those that leave casing to piping joints intact, ie. horizontal split-casing types for large centrifugal pumps and horizontal, back pull-out types for smaller units. Where a significant saving in floor space or improvement of layout can be shown, a vertical pump may be acceptable.

Pumps shall be capable of continuous operation with minimum maintenance.

2.18 PIPEWORK

2.18.1 General

During the contract engineering, the Bidder shall supply to the Engineer schedules of the pipework provided under this Contract. These schedules shall state, for each pipework system or part of a pipework system, the design and operating pressures and temperatures, the fluid transmitted, the piping and valve materials, the types of valves, any corrosion allowances, the pipework design code, insulation proposals, pipe supports and any other data relevant to the mechanical design of the pipework system or part of a pipework system.

All piping shall be routed to provide a neat and economical layout requiring the minimum number of fittings. Piping shall be arranged so that full access is provided for the operation and maintenance of equipment and so that removal or replacement of equipment can be achieved with the minimum dismantling of piping.

2.18.2 Internal cleaning of pipes

The Bidder is to be responsible for ensuring that the internal surface of each pipe line is thoroughly clean both during erection and before the pipe

line is placed in commission.

The procedure adopted by the Bidder is to include the following:-

i) Thorough cleaning of all internal surfaces prior to erection to remove accumulations of dirt, rust, scale etc., and welding slag due to site welding before erection.

ii) Thorough cleaning of all pipework after erection by blowing through to atmosphere to ensure that no extraneous matter is left in the system.

The Bidder is to provide all necessary facilities for carrying out these requirements.

2.18.3 Pipe Supports and Anchors

Pipework shall be supported and anchored in an appropriate manner in accordance with the provisions of US Standard ANSI B31.1 or the Standard to which the pipework is designed.

The whole of the pipework and accessories included in this Contract are to be supported and mounted in an approved manner. All necessary slings, saddles, structural steelwork, foundation bolts, fixing bolts and all other attachments are to be supplied.

The number and positions of all supports and the maximum weight carried by a support is to be subject to the approval of the Engineer.

2.19 VALVES

2.19.1 General

All valves shall be suitable for the service conditions under which they are required to operate. The design, construction and choice of materials shall take into account all operational deviations including pressure surge and thermal shock.

2.19.2 Hand Operation Requirements

All valve hand operating mechanisms shall be easily operable by one man. The mechanisms shall be such that the total force at the rim of the handwheel or other point of application of manual action shall not need to exceed 400N (normally 200N pull plus 200N push) to exercise any valve. Special attention shall be given to the operating mechanism for large size valves with a view to ensuring that a minimum of maintenance is required and to obtaining quick and easy operation.

All valves shall be closed by rotating the handwheels in a clockwise direction when looking at the face of the handwheel. In cases where the

handwheel is not directly attached to the valve spindle suitable gearing shall be introduced to ensure clockwise closing. The face of each handwheel shall be clearly marked "open" and "shut" or "closed" with arrows indicating the direction of rotation to which they refer.

Plastic valve handwheels will not be acceptable, except where such handwheels are in the Employer's best interests. All valve spindles shall be fitted with indicators so that the valve opening can be readily determined. In the case of valves fitted with extended spindles, indicators shall be fitted both to the extended spindles and to the valve spindles.
Valves of 50mm nominal bore and over are to be provided with indicators showing when the valve is open or closed.

All valve hand wheels are to be fitted with nameplates complying with this Specification.
Suitable means are to be provided to protect the operating mechanisms of all valves against mechanical damage and dust or dirt.

Valves which it will be necessary to lock in the open or closed position are to be provided with a non-detachable locking arrangement.

2.20 PRESSURE VESSELS

All vessels shall be designed, constructed and otherwise comply with appropriate international or national pressure vessel design codes, unless the vessel in question falls into one of the following groups:-

(a) vessels with a water containment capacity of less than 454 litres for the containment of water under pressure, including those containing air, the compression of which serves only as a cushion.

(b) hot water storage vessels heated by steam or any other indirect means when none of the following limitations is exceeded:-

i) a heat input of 58kW
ii) a water temperature of 93˚C
iii) a nominal water containment capacity of 454 litre.

(c) vessels having an internal or external design pressure not exceeding 1.03 bar gauge, this design pressure being not less than the maximum expected difference that may exist between the inside and outside of the vessel at any time.

(d) vessels having an internal diameter not exceeding 150 mm.
(e) vessels and equipment covered more appropriately by boiler or pipework design codes.

Should any difficulty arise in the decision as to whether a particular vessel shall comply with a pressure vessel code, the vessel shall be "coded" unless specifically excluded in clause U- 1 of the US ASME Boiler and

Pressure Code, Section VIII, division 1, dealing with the scope of that code.

Notwithstanding the foregoing exclusions (a) to (e), if it is stated elsewhere in the Specification that a particular vessel shall comply with a pressure vessel design code, then a vessel complying with a suitable design code shall be provided.

In respect of the design codes to which "coded" vessels shall comply, attention is drawn to the provisions of this Specification relating to design codes and standards.

2.21 LUBRICATION

The Contract is to include for the supply of flushing oil for each lubrication system when the item of plant is ready for preliminary tests and the first filling of approved lubricants for the commercial operation of the plant.

A schedule of the oils and other lubricants recommended for all components of the Contract Works is to be submitted to the Engineer for approval. The number of different types of lubricants is to be kept to a minimum. Copies of this schedule shall be included in both the draft and final copies of the operating and maintenance instructions. In the case of grease lubricated roller type bearings for electric motors a lithium based grease is preferred.

The Bidder is to supply at least one grease gun equipment for each type of nipple provided. Where more than one special grease is required, a grease gun for each special type is to be supplied and permanently labelled.

2.22 OIL LEVEL INDICATORS

Oil level indicators of approved design are to be fitted to all oil containers such as transformer tanks etc.

The indicators are to show the level at all temperatures likely to be experienced in service, are to be marked with the normal level at 20℃ clearly visible from normal access levels and are to be easily dismantled for cleaning. In addition, the normal filling level of all removable containers is to be marked on the inside.

2.23 PRESSURE GAUGES

Pressure gauges are to comply with the requirements of BS 1780.

All pressure gauges are to be fitted with stop cocks immediately adjacent to each gauge and all pressure gauge piping is to be fitted with an isolating valve at each point of connection to the main system. Where pressure gauges are mounted on panels, the stop cocks are to be suitable for the connection of a test gauge.

Gauges shall be calibrated to read pressure at the tapping point and a sealed pressure transmitting system shall be used.

All pressure gauges are to be clearly identified by means of labels of approved type and lettering.

All pressure gauge piping is to be of corrosion resistant steel or copper tube.

2.24 THERMOMETER POCKETS

Thermometer pockets and instrument connections of an approved pattern are to be fitted in such positions as may be determined to suit the operation and testing of the plant to the approval of the Engineer. A thermometer pocket is to be fitted adjacent to each point of connection for distant remote temperature indication unless specifically stated to the contrary. Where necessary, the pocket is to be of approved alloy material suitable for the required service.

All thermometer pockets are to comply with the requirements of BS 2765.

2.25 GAUGE CUBICLES AND PANELS

Gauges and instruments are to be grouped whenever possible and housed in suitable cubicles. Where circumstances do not justify cubicle accommodation, they may be secured to flat back panels but in such cases the approval of the Engineer is first to be obtained.

Cubicles are to be sheet metal having a thickness of 3mm. The construction shall employ folding technique with the use of standard rolled sections or other reinforcement where necessary. The stiffness shall be such as to prevent maloperation of relays or other apparatus by impact. The front of the panel is to have a smooth well finished surface and, if of the "desk" type, the desk is not to protrude so far as to hinder the easy reading of instruments and the operation of the controls.

2.26 LOCKING FACILITIES

Locking facilities including padlocks shall be provided under this Contract for:

(a) Control position selector switches in all positions provided.

(b) Marshalling, operating and terminal kiosks or cubicle access doors and panels.

(c) Isolating valves in open or closed positions.

Locking facilities shall be of an approved dead latch type. Three keys shall be supplied for each lock and all locks and keys shall be

non-interchangeable.

Where a set of locks is provided under a particular section of the Plant, a group master key shall be supplied in addition.

A schedule of locks and keys shall be submitted to the Engineer for approval.

All locks and padlocks shall be of brass and where they are fitted to switchboards or similar cubicles shall have the visible parts chromium plated.

Where a group of locks is supplied under any part of the Contract, a rack or cabinet of approved design shall be supplied for the accommodation of all padlocks and/or keys while not in use. The padlocks and keys shall be engraved with an agreed identifying code or inscription and this shall be repeated on the racks or cabinets on engraved labels.

Where a mechanism is to be locked in a specific position, provision shall be made at that part of the mechanism where the operating power is applied and not to remote or ancillary linkages.

Provision for locks shall be designed, constructed and located on the equipment so that locks will remain serviceable in the climatic conditions specified without operation or maintenance for continuous periods of up to two years and with suitable maintenance shall be fit for indefinite service.

2.27 ELECTRICAL EQUIPMENT

2.27.1 General

The works shall be designed to ensure continuity of operation under all working conditions obtaining at the Site as the first consideration and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of equipment and of the works, to ensure the safety of personnel concerned with the operation and maintenance of the works.

Outdoor equipment shall be designed so that water cannot collect at any point. The undersides of all tanks shall be ventilated in an approved manner to prevent corrosion.

Mechanisms shall be constructed to prevent sticking due to rust and corrosion, and the bearings of exposed operating shafts shall be designed so as to prevent moisture seeping along shafts into the interior of equipment.

Corresponding parts of similar equipment, and equipment liable to renewal, shall be fully interchangeable and the Bidder will be required to demonstrate this feature to the Engineer's and Employer’s satisfaction.

All equipment shall operate without undue vibration and with the least practical amount of noise.

All equipment shall be designed to minimise corona or other electrical discharges, to comply with local electromagnetic compatibility (EMC) standards and in accordance with IEC 61000.

All electrical components shall be adequately rated for their most onerous duty and the specified ambient temperature. When equipment is mounted in panels, cubicles etc., due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or derated as necessary to suit the most onerous operating temperatures within the enclosure.

Except where a different meaning is stated in an equipment standard, the term "low voltage" (LV) shall refer to voltages up to and including 1 kV, and "high voltage" (HV) shall refer to all voltages exceeding 1 kV.

Fuses, circuit-breakers and other electrical switchgear components shall comply with the relevant clauses, for low voltage ac switchgear.

2.27.2 Electrical Equipment Enclosures

Equipment enclosures for electrical equipment shall comply with IEC 60079, IEC 60529 and IEC 60947-1 as applicable. Equipment enclosures for use in hazardous areas other than explosive gas atmosphere shall comply with National and Local Regulations relating to this application.
Unless otherwise specified, minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows: -

(a) Indoors only in totally enclosed rooms with provision for limiting ingress of dust:
IP 31

(b) Indoors, except as noted otherwise: IP 54

(c) Outdoors, and indoors in areas subject to water spray, or heavy condensation:
IP55W

The enclosure classification of main and auxiliary cable boxes with the

cable(s) terminated shall not be less than that of the associated equipment, subject to a minimum classification of IP54.

2.28 CURRENT RATINGS

2.28.1 Normal Current Ratings

Current ratings in accordance with IEC 60059 shall be adopted, unless otherwise agreed with the Engineer.

Every current carrying part of the equipment shall be capable of carrying its site rated current continuously under the site ambient conditions as specified and shall not be rated on the basis of air conditioned rooms even when these are specified. In no conditions shall the specified maximum temperature be exceeded.

The current ratings specified are the continuous current ratings required at the Site, under the specified maximum temperature conditions.

2.28.2 Temperature Rise

Full provision shall be made for solar heat gain on all outdoor apparatus and any differential temperatures attained as a result of the impingement of solar heat.

The allowable temperature rise shall be in accordance with the relevant Standard, except where the ambient temperature exceeds the maximum permitted in that Standard, when the permitted temperature rise shall be reduced by one degree Celsius for every degree Celsius the maximum ambient temperature exceeds the maximum permitted in the Standard.

To allow for high ambient site temperatures, the allowable temperature rise for transformers shall be reduced by a maximum of 10℃.

In such cases where the Bidder is unable to guarantee the permitted maximum temperature reached under site conditions, taking account of solar heating, then sunshades shall be provided to the Engineer's approval.

The maximum temperature attained by components under the most onerous service conditions shall not cause damage or deterioration to the equipment or to any associated or adjacent components.

The Bidder shall submit his calculations to the Engineer to prove that all plant has been sufficiently derated to suit the site conditions and any changes required by the Engineer shall be made at no extra cost.

2.28.3 Short-time Current Ratings

Electrical equipment shall be adequately supported and braced to

withstand the forces associated with the maximum short-circuit currents specified or pertaining, whichever is the greater, and assuming that the inception of the short-circuit is at such a time that gives maximum peak currents. No provision for current decrement shall be made unless specifically permitted by the appropriate Standard, or elsewhere in this Specification.

Equipment shall be so constructed as to withstand the specified maximum short-circuit currents for the time specified in the Schedules without the temperature exceeding the specified maximum short-time temperature or value stated in the relevant standard, under these conditions. The equipment shall be considered as being operated at the maximum permitted continuous temperature prior to inception of the short circuit.

The final temperature attained as a result of the passage of short-circuit current shall not cause permanent damage, or deterioration sufficient to reduce the normal operating characteristics below the specified or most onerous operating requirements, whichever is the highest.

2.29 VOLTAGE RATINGS

2.29.1 Normal Voltage Ratings

Unless otherwise specifically stated, any reference to voltage rating shall be deemed to refer to the nominal rated voltage or voltages of electrical equipment. Standard voltage levels in accordance with IEC 60038 shall be adopted, unless otherwise specified by or agreed with the Engineer.

All electrical equipment shall, except where otherwise specified, be capable of continuous operation at a voltage in the range of ±15% of the nominal voltage and at a frequency in the range of 47 to 51 Hz coincidentally without deterioration.

The temperature rise of electrical equipment continuously operating at the specified extreme voltage and frequency shall not exceed the temperature rise when operating at nominal voltage and frequency by more than 5℃.

2.29.2 Short-time Voltage Ratings

All electrical equipment shall be so designed such as to withstand abnormal system voltages as required by the applicable BS, IEC or acceptable International Standard.

2.30 ELECTRICAL INSULATION

Insulating materials shall be suitably finished so as to prevent deterioration of their qualities under the specified working conditions. Account shall be taken of the IEC 60085 recommendations.

Ebonite, synthetic resin-bonded laminated material and bituminised

asbestos cement-bonded panels shall be of suitable quality selected from the grades or types in the appropriate IEC, or approved National Standard.

The insulation of all machine windings, solenoids, etc. other than those immersed in oil or compound, shall be of Class F materials, unless otherwise specified elsewhere.

All cut or machined surfaces and edges of resin-bonded laminated materials shall be cleaned and then sealed with an approved varnish as soon as possible after cutting.

Linseed oil and untreated materials of fibre, leatheroid, presspahn, asbestos or other similar hygroscopic types of materials shall not be used for insulation purposes. Untreated leatheroid and presspahn may be used for mechanical protection of winding insulation.

The use of asbestos is not permitted without the permission of the Engineer.

Wherever practicable, instrument, apparatus and machine coil windings, including wire wound resistors, with the exception of those immersed in oil or compound, shall be thoroughly dried in a vacuum or by other approved means and shall then be immediately impregnated through to the core with an approved insulating varnish. Varnish with a linseed oil base shall not be used.

No material of a hygroscopic nature shall be used for covering coils. Where inter-leaving between windings in coils is necessary, only the best manila paper, thoroughly dried, which permits penetration by the insulating varnish or wax, shall be used.

Polychlorinated Biphenyl (PCB) type materials shall not be used anywhere in the equipment or in any component.

2.31 INSULATING OIL

Insulating oil shall comply with the requirements of IEC 60296. Insulating oil shall be provided by the Bidder for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums. The Bidder shall provide at no additional cost any oil treatment facilities he may require for his own use in order to ensure that insulating oil meets the requirements of the specification.

2.32 CONTROL AND SELECTOR SWITCHES

Control switches shall be of the three position type with a spring return action to a central neutral position and without a locking feature.

Circuit breakers shall have control switches which shall be labelled open/N/close or (O/N/I) and arranged to operate clockwise when closing

the circuit breakers and anti-clockwise when opening them.

Control switches of the discrepancy type shall be provided where specified. Such discrepancy control switches shall be arranged in the lines of the mimic diagram. Such switches shall include lamps and be of the manually operated pattern, spring loaded such that it is necessary to push and twist the switch past its indicating position for operation. The lamp shall be incorporated in the switch base and shall flash whenever the position of the controlled device is at variance with the position indicated by the control switch. Hand dressing of the control switch to the correct position shall cause the lamp to extinguish.

Pushbutton test switches shall be provided along the control panel which will illuminate all indicating discrepancy lamps as well as spare lamps on the control panels. The scheme shall be complete with all necessary diodes and other equipment required for satisfactory operation.

Switches for other apparatus shall be operated by pushbuttons, shrouded or well recessed in their housings in such a way as to minimise the risk of inadvertent operation.

Multi-position selector switches shall have a lockable stayput action. Each position of the selector switches shall be suitably labelled to signify the functions in accordance with the approved wiring diagrams. The switch handle shall be of the pistol grip spade type to the approval of the Engineer.

It shall not be possible at any time to close any switching device from more than one location simultaneously, and suitable lockable selector switches shall be provided to meet this requirement. Tripping signals from all locations shall function at all times.

Particular variations of the above requirements may be agreed with the Engineer for special instrument or control equipment, viz. main control room desks and panels, and electrical equipment cubicles.

The contacts of all control and selector switches shall be shrouded to minimise the ingress of dust and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

2.33 PANELS, DESKS AND CUBICLES

Unless otherwise specified, panels, desks and cubicles, shall be of floor-mounted and free-standing construction and be in accordance with the enclosure classification specified elsewhere. All control and instrumentation panels in any one location shall be identical in appearance and construction. Where new panels are supplied for existing substations, these shall match existing panels in appearance, arrangement and devices and colour finishes.

Panels shall be rigidly constructed from folded sheet steel of 3mm minimum

thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess.

Overall height, excluding cable boxes, shall not exceed 2.5m. Operating handles and locking devices shall be located within the operating limits of 0.95m and 1.8m above floor level. The minimum height for indicating instruments and meters shall be 1.5m unless otherwise approved by the Engineer.

Panels shall be mounted on an approved form of anti-vibration mounting whenever necessary.

All panels, desks and cubicles shall be vermin-proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the Engineer.

All cubicles, desks and panels shall be provided with a natural air circulation ventilation system. All control equipment shall be designed to operate without forced ventilation.

For outdoor equipment, metal to metal joints shall not be permitted and all external bolts or screws shall be provided with blind tapped holes where a through hole would permit the ingress of moisture. For harsh environments, all nuts, bolts and washers shall be tropicalised as appropriate in accordance with Clause 2.10.2.

Door sealing materials shall be provided suitable for the specified site conditions. Doors shall be fitted with handles and locks. Where walk-in type panels are supplied the door shall be capable of being opened from inside the panel without the aid of a key after they have been locked from the outside. Hinges shall be of the lift-off type, and shall permit the doors when open, to lie back flat so as not to restrict access. Means shall be provided for securing the doors in the open position.
Cubicles and cubicle doors shall be rigidly constructed such that, for example, door mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

The bottom and/or top of all panels shall be sealed by means of removable gasketted steel gland plates. Gland plates for bottom entry shall be at least 250mm above the floor of the cubicle.

Panels shall be suitably designed to permit future extension wherever appropriate or specified.

Each panel shall include rear access doors internal power sockets and door-operated internal lighting, and be clearly labelled with the circuit title at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltages higher than 125V (nominal) shall be partitioned off and the voltage clearly labelled. Each relay and electronic

card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes.

Terminations, wiring and cabling shall be in accordance with the requirements of this section of the specification.

For suites of panels interpanel buswiring shall be routed through apertures in the sides of panels and not via external multicore cabling looped between the panels.

All panels, whether individually mounted or forming part of a suite, shall incorporate a common internal copper earthing bar onto which all panel earth connections shall be made. Suitable studs or holes to the Engineer's approval shall be left at each end of the bar for connection to the main station earthing system and possible future extension.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel sides and not by interconnecting external cabling.

Where intrinsically safe circuitry is routed from a hazardous area to a safe area instrument panel, it shall be connected through Zener Barriers located in the safe area (instrument panel) of suitable rating and mounted on an insulated earthing busbar having facilities for connection of a separate dedicated outgoing cable to a "clean earth" system.

Control supplies in desks, panels and cubicles shall be derived from a duplicate standby/UPS system, except if specified otherwise in this specification. The following alarms shall be provided to monitor the systems: voltage high, voltage low, no volts and earth fault. The alarms shall be signalled to the Control Room.

Instruments having pressure pipe connections containing oil, water, steam or flammable or toxic fluids shall be excluded from the Control Room.

All cubicles, desks and panels shall be painted externally with a high gloss paint of Munsell 5Y-7/1 colour. The interiors of all cubicles, desks and panels shall be painted matt white.

All cubicles, or panels mounted external to control and apparatus rooms shall be fitted with thermostat controlled anti-condensation heaters.

2.34 INSTRUMENTS & METERS

2.34.1 Indicating Instruments

All indicating instruments shall be of the flush mounted pattern with dust and moisture proof cases complying with BS 2011, Classification 00/50/04, and shall comply with IEC 51-1.

Unless otherwise specified, all indicating instruments shall have 96mm or 144mm square cases to DIN standard or equivalent circular cases.

Instrument dials in general should be white with black markings and should preferably be reversible where double scale instruments are specified.

Scales shall be of such material that no peeling or discolouration will take place with age under humid tropical conditions.

The movements of all instruments shall be of the dead beat type. Wherever possible, instruments shall be provided with a readily accessible zero adjustment.

2.34.2 Electrical Meters

All electrical meters shall comply with IEC 521 and, unless otherwise specified, shall be of accuracy Class 0.2. Three-phase power measuring instruments shall be of the three-phase unbalanced load pattern wherever the current and voltage references permit.

Where precision grade metering is specified meters shall be calibrated to precision grade accuracy to IEC 521. Due allowance shall be made for the errors of current and voltage transformers with which they shall work and whose accuracy class shall be Class 0.2.

Where commercial grade metering is specified the meters shall be calibrated to commercial grade accuracy to IEC 521.

Meters shall be single directional and shall be fitted where required with suitable devices for the transmission of impulses to a summator. Var-hour meters shall be complete with phase shifting transformers as necessary.

Front of panel test terminal blocks shall be provided for all meters.

Summators shall be equipped to summate the circuits specified and shall be equipped where required with suitable contacts for the re-transmission of impulses to a printometer. They shall register in kilowatts the value of the impulses received from each kilowatt-hour meter. Printometers shall be of an approved type having the specified demand interval.

Each feeder shall be provided Main 1 and Main 2 energy meters. The energy meter shall be 3-element, 4-wire arrangement of programmable digital type and shall have proven performance and shall consist of different types, either from the same manufacturer or different manufacturers. The accuracy class of the energy meter shall be 0.2.

2.35 INDICATING LAMPS AND FITTINGS

All indicating lamps shall be adequately ventilated and as far as practicable, lamps of a common type and manufacture shall be used throughout the Contract.

Lamps shall be easily removed and replaced where possible from the front of the panel by manual means preferably not requiring the use of extractors.

Where specified every circuit breaker panel shall be equipped with one red and one green indicating lamp, indicating respectively circuit closed and circuit open and an amber lamp for indicating 'auto-trip'. Where specified for in the lines of mimic diagrams, indicating lamps may be of the three-lamp single-aspect type.

The variety of indicating lamps provided shall be rationalised to reduce maintenance and spares requirements. The lamps shall be clear and shall fit into a lamp holder. The rated lamp voltage shall be at least 20% in excess of nominal supply voltage, whether A.C. or D.C. The lamps shall have an operating life of at least 10,000 hours, under site conditions. In the event that other indicating devices, such as light emitting diodes, are used in place of lamps then these shall have the same life expectancy and performance capability as the lamps they replace.

The lamp glasses shall comply with IEC 60073 and be in the standard colours, red, green, blue, white and amber. The colour shall be in the glass and not an applied coating. Transparent synthetic materials may be used instead of glass subject to the approval of the Engineer.

Where illuminated pushbuttons are used for control purposes, the illuminated pushbuttons shall be engraved with a clear instruction such as 'push to open' or 'push to close', and the lamp shall illuminate in accordance with the above colour code after the instruction has been carried out and the device has operated.

Unless otherwise agreed with the Engineer all lamp colours shall conform to the following practice: -

Red - energised or operative position

Green - de-energised or inoperative position

Amber - fault or abnormal condition

White - healthy or normal condition

Blue - other purposes, to be used with descriptive label

Lamp test facilities shall be provided for all switchboards, control panels etc. to enable all lamps to be tested whilst the equipment is in service. Operation of the lamp test facility shall not cause any other device to operate.

Indication circuits shall be fused.

2.36 ANTI-CONDENSATION HEATERS

All switchboards, panels, cubicles and the like shall incorporate thermostat controlled electric heaters capable of providing movement of sufficient heated air to avoid condensation. The apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energised while the apparatus is in operation.

The switchboard anti-condensation heaters shall be fed from an LV single phase and neutral supply, manually switched by a two-pole switch with red lamp, mounted on the back of the board, panel or cubicle and buswired through the board. Labels shall be provided on the switch stating "Heater Supply". Heater terminals shall be shrouded and labelled "Heater".

Motor anti-condensation heaters where fitted shall be fed from an LV single phase and neutral supply buswired through the board. The supplies shall be individually fused and will be switched by auxiliary contacts on the contactor and isolated by auxiliary contacts on the contactor isolator.

2.37 CONTROL AND INSTRUMENT PANEL WIRING, CABLETERMINATIONS AND TERMINAL BOARDS

2.37.1 General

All electrical equipment mounted in or on switchgear, panels and desks, shall have readily accessible connections and shall be wired to terminal blocks for the reception of external cabling.

The wiring shall comply with BS 6231 and shall be capable of withstanding without deterioration the conditions at Site, due allowance being made for such temperature conditions as may arise within any enclosure. The insulating material shall be flame retardant in accordance with IEC 60332.

All wiring shall be of adequate cross-sectional area to carry prospective short-circuit currents without risk of damage to conductors, insulation or joints.

The following classes of copper conductor, as defined in IEC 60228, shall be used for panel wiring:

(a) Class 1 conductors up to a maximum of 0.9 mm diameter where necessary for wire-wrapped terminations and similar techniques,

(b) Class 2 conductors except where specified otherwise,

(c) Class 5 and Class 6 conductors between points subject to relative movement.

The following minimum conductor sizes shall be used:

(a) 2.5 mm2 for current transformer secondary circuits with a rated secondary current of not exceeding 1A.

(b) 1.5 mm2 except where specified otherwise,

(c) 0.5 mm2 for alarm and indication circuits with a continuous or intermittent load current not exceeding 1A.

Where an overall screen is used, this shall be a metallic screen or low resistance tape, with a drain wire as above.

Wiring shall be supported using an insulated system which allows easy access for fault finding and facilitates the installation of additional wiring.

Small wiring passing between compartments which may be separated for transport shall be taken to terminal blocks mounted separately from those for external cable connections.

Connections to apparatus mounted on doors or between points subject to relative movement shall be arranged so that they are subjected to torsion rather than bending.

Ribbon cables or similar preformed cables with plug and socket connectors may be used for light current wiring. Plug and socket connectors shall be polarised so that they can only be inserted into one another in the correct manner.

If so required, the Bidder shall submit for the Engineer's approval samples of the types of wire, numbered ferrules, and terminal washers or lugs as appropriate which he propose to use.

2.37.2 Identification of Wires

All wiring and cores in control and instrument cables shall be identified in accordance with the associated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colours, except when an automatic or proprietary system of wiring is used, e.g. point-to-point wiring on a mother board.

When a wire numbering system is used, it should be in accordance with a functional marking system. Both ends of every wire and core in control and instrument cables shall be fitted with interlocking ring ferrules of white

insulating material indelibly marked with black characters, complying with BS 3858. Heat shrink marking sleeves may be used, but adhesive markers are not acceptable.

When plug and socket connectors are used, they shall be uniquely identified as mating pairs and each connector pin shall be numbered. Wiring which is permanently connected to plugs or sockets need not be identified.

Each core of multipair wiring shall be identified by colour and terminal block identification together with an identification tracer per bundle.

Permanent identification of all terminals, wires and terminal blocks shall be provided.

A consistent system of wiring numbering shall be used throughout the plant, and it shall be agreed with the Engineer at the start of the Contract.

2.37.3 Terminals and Terminal Blocks

Terminal blocks shall have separate terminals for internal and external connections, and not more than one wire shall be connected to each terminal.

Adjacent terminals to which wires of different voltage, polarity or phase are connected shall be separated by a protruding insulating barrier. This requirement also applies to terminals carrying wires of the same voltage but originating from different sources.

Trip circuit wiring and instrument transformer secondary wiring shall be connected using hook type crimped terminations in screw clamp, spring loaded insertion type terminals.

Where clamp type terminals are used, Class 1 and Class 2 conductors may be terminated without lugs. Crimp lugs shall be used for Class 5 and Class 6 conductors. Means shall be provided for retaining the identifying ferrules of the wire end when it is disconnected. Pinch screw type terminals shall not be permitted.

Subject to approval of the Engineer, "wire-wrap", "termi-point" or equivalent methods of terminations of single strand conductors may be used.

Wires shall be grouped on the terminal boards according to their functions. All terminal blocks shall provide a degree of protection of not less than IP2X when correctly installed, either inherently or by provision of insulating covers.

Terminal boards shall be mounted vertically, not less than 150mm above the gland plates, and spaced not less than 100mm apart, on the side of the

enclosure and set obliquely towards the rear doors.

Sufficient terminals shall be provided to permit all cores on multicore cables to be terminated. Terminals for spare cores shall be numbered and be located at such position as will provide the maximum length of spare core. At least 10% spare terminals shall in all cases remain after commissioning.

The tails of multicore cables shall be bound and routed so that each tail may be traced without difficulty to its associated cable. All spare cores shall be made off to terminals.

When two lengths of screened cable are to be connected at a terminal block (i.e. junction box) a separate terminal shall be provided to maintain screen continuity.

In the main and local control and equipment rooms means shall be provided on the terminal blocks of panels, desks, cubicles, etc., for testing all the instrument circuits without the need to remove the internal or external wiring from the block.

The Bidder shall submit full details and specification of the proposed means of termination where wire wrapping, soldering and similar methods are used. The adopted methods shall be to the Engineer's approval.

The Bidder shall identify all special tools, such as wire wrapping tools required for termination, and shall make provision for their supply in sufficient numbers.

The use of pre-formed factory tested cable connections to field mounted marshalling boxes shall be to the Engineer's approval.

2.38 CABLE BOXES AND GLANDS

2.38.1 General

Electrical equipment shall be provided with all necessary cable boxes, which shall be complete with all required fittings. All cable boxes shall be of adequate size to allow for the correct termination of the cable sizes required or specified, taking into account the crossing of cores to achieve the correct phasing, and to accommodate all cable fittings, including stress cones or other means of cable insulation grading, if required. All cable boxes shall be designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

All main cable boxes shall be air insulated for the termination of all types of cable at voltages up to and including 33 kV nominal system voltage, unless otherwise specified elsewhere in this Specification. Compound-filled cable boxes may only be used for paper insulated cables, where specified elsewhere.

The enclosure classification of main and auxiliary cable boxes on motors with the cable(s) terminated shall not be less than that of the associated motor, subject to a minimum classification of IP54.

Clearance and creepage distances shall be adequate to withstand the specified alternating current voltages and impulse voltages for service under the prevailing site conditions. Means shall be provided for preventing accumulation of dirt, dust, moisture, vermin or insects such as to maintain the anticipated life of the equipment.

The terminals for 3 phase cables shall be clearly marked with the specified phase designations to enable the cables to be terminated in the correct sequence.

Flexible connections shall be provided between cable lugs and bushings for all cables of 300 mm2 section and greater.

There shall be no possibility of oil entering the cable box from an associated oil filled compartment.

Inner sheaths shall be arranged to project at least 25mm above the gland plate to avoid moisture collecting in the crutch.

All cable boxes shall be designed to withstand the high voltage d.c. cable tests prescribed in IEC 60055, IEC 60502 or other applicable standard.

Cable lugs and terminations for the receipt of all power, control and instrumentation cable cores shall be provided.

Where air insulated terminations are used, the cable crutch within a cable box or equipment panel shall be protected by the use of a heat-shrink plastic trifurcating sleeve or equivalent placed over the cores and crutch.

The Bidder shall provide full information and instruction for his proposed method of terminating HV cables.

Removable gasketted steel gland plates shall be provided for multicore cables. The cable entry into the cable box shall be arranged so that there is adequate space to manipulate the cable for glanding and termination.

When single core cables are used, particularly for currents in excess of 500A, adequate steps must be taken to minimise the effects of eddy currents in the gland and bushing-mounted plate.

Gland plates for externally mounted marshalling boxes shall be in the form of removable gasketted steel plates, forming part of the underside of the box. Indoor marshalling boxes may be fitted with gland plates on all four sides.

2.38.2 Additional Requirements for Compound-filled Cable Boxes

Cable boxes for paper insulated cables shall be complete with universal tapered brass glands, insulated from the box in an approved manner and including an island layer for testing purposes, together with removable shorting links.

Filling and venting plugs, where required, shall be positioned so as to avoid the possibility of air being trapped internally and adequate arrangements shall be made for expansion of compound, etc.

Compound-filled chambers shall be clean and dry and at such a temperature before filling that the compound does not solidify during the filling process. Filling orifices shall be sufficiently large to permit easy and rapid filling.

2.38.3 Cable Glands

Cable glands for extruded solid dielectric insulated cables (PVC, EPR, XLPE) shall be of the compression type and as specified in BS 6121 Part 1.

All glands shall be provided with an earthing tag or equal facility. For cables having conductors not larger than 4mm^2 serrated washers may be used in place of earthing tags to provide earth continuity.

Glands for armoured or screened cables greater than or equal to 240 mm2 and all insulated glands for power cables shall be provided with an integral earthing lug. On cable glands up to and including 40 mm nominal size, the earthing connection shall have a short circuit rating of at least 25 kA for 1 second, and of at least 40 kA for 1 second on larger sizes.

Insulated glands shall be provided with removable connections for bonding across the gland insulation. The gland insulation shall withstand a wet insulation voltage withstand test of at least 2 kV a.c. for 1 minute.

Under conditions of severe corrosion, corrosion-resistant cable glands complying with BS 6121 Part 3 may be used, or the Bidder may use an alternative solution with the approval of the Engineer.

Polymeric cable glands complying with BS 6121 Part 2 may be used, but only when terminating unarmoured cables.

Glands for MICS cables shall be to the approval of the Engineer.

2.39 BOX-FILLING COMPOUNDS

The type of compound shall be to the approval of the Engineer, who shall be supplied with sufficient information by the Bidder. The Bidder shall supply all compound required together with an additional quantity of not

less than 10% of normal requirements.

Where hot-pouring compounds are employed the pouring temperature shall be verified by use of thermometers or similar instruments and the metallic case of all joints and terminal boxes shall be adequately pre-warmed to drive off moisture.

The Bidder shall take particular care to adhere to the recommended topping-up procedures and to ensure that no leakage or migration of the filling compound occurs. Should leakages occur during the maintenance period the Engineer will require the joint to be re-made at the Bidder's expense.

2.40 OIL OR COMPOUND-FILLED CHAMBERS

All joints of oil- or compound-filled fabricated chambers, other than those which have to be broken, shall be welded and care shall be taken to ensure that the chambers are oil-tight. Defective welded joints shall not be repaired but maybe re-welded subject to the written approval of the Engineer.

Insulating compound shall comply with BS 1858.

The correct oil or compound filling level shall be indicated on the inside and outside of chambers.

2.41 JOINTS AND GASKETS

All joint faces are to be flat and parallel to the approval of the Engineer and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil-resisting synthetic rubber gaskets are not permissible, unless the degree of compression is accurately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bonding medium.

2.42 VALVES ON ELECTRICAL EQUIPMENT FLUID LINES AND VESSELS

Valves shall comply with the requirements of Clause 2.19.

All drain and filter valves shall be provided with gun metal adaptors suitable for connecting a flexible hose having a screwed coupling of approved size. Captive-screwed caps shall be provided for all such adaptors.

2.43 JUNCTION AND MARSHALLING BOXES

Junction and marshalling boxes for use in non-hazardous areas shall be of substantial sheet aluminium anodised coating construction to prevent corrosion, having an enclosure classification in accordance with the requirements of clause 2.27.2. They shall be fitted with external fixing lugs

and finished in accordance with the requirements of the specification for cleaning, painting and finishing. The boxes shall allow ample room for wiring, with particular regard to the routing of wires from the point of entry. Boxes made from aluminium shall be subject to agreement with the Engineer.

Outdoor boxes shall have an anti-condensation finish and all boxes shall be designed such that any condensed water cannot affect the insulation of the terminal boards or cables. No cables shall be terminated into the top of outdoor boxes unless specifically approved by the Engineer.

All outdoor kiosks, cubicles and panels shall be provided with sun/rain shades. All kiosks, cubicles and panels not in air-conditioned rooms shall be provided with thermostat controlled anti-condensation heaters.

All kiosks, and cubicles shall be fitted with door operated internal illumination lamps.

All necessary gland plates shall be provided undrilled.

Boxes shall be complete with suitably inscribed identification labels.

Boxes for use in hazardous areas shall have all entries factory pre-drilled. Every unused screwed entry shall be sealed by means of a tamperproof screwed plug in accordance with IEC 60079.

Hazardous area boxes with bolted or screwed lids shall require the use of special keys or spanners, for lid removal.

Where weatherproof types of hazardous area boxes are not available, the gaps should be protected against the ingress of moisture, by an approved means, compliant with local standards.

All box covers are to be arranged for padlocking and padlocks with keys shall be supplied.

All boxes shall be provided with adequate earthing bars and terminals.

2.44 CONDUIT AND ACCESSORIES

Conduit installations shall comply with IEC standards 60364, 60621 and 60981. Installations shall also be compliant with local regulations, unless otherwise approved by the Engineer.

All conduit and conduit fittings shall comply with IEC 60423. Unless otherwise approved, all conduit and conduit fittings shall be threadable steel conduit with minimum enclosure classification IP55, heavy mechanical protection and high resistance to corrosion inside and outside.
No conduit smaller than 20mm diameter shall be used.

Standard circular boxes or machined face heavy duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanised, weatherproof and fitted with external fixing lugs.

Where conduit is terminated so that the bare end of the conduit is exposed the conduit end shall be fitted with a brass bush.

The use of running threads, solid elbows and solid tees will not be permitted.

Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10m in straight-through runs.

Conduit runs shall be in either the vertical or horizontal direction, unless otherwise approved, and shall be arranged to minimise accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.

Conduits shall be supported on heavy galvanised spacer saddles so as to stand off at least 6mm from the fixing surface.

All conduits run in any circuit are to be completed before any cables are pulled in.
Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate earth continuity conductor shall be provided.

2.45 TRUNKING

Steel trunking may be used for running numbers of insulated cables or wires in certain positions to the approval of the Engineer. The trunking thickness shall not be less than 1.2 mm.

Connection of conduit to trunking shall be with socket and male bush. All trunking shall be manufactured from hot-dip zinc coated steel sheet and conform to IEC 1084.

2.46 ELECTRIC MOTORS

2.46.1 General

Motors shall comply with the requirements of IEC 60034 and IEC 60072 as amended and supplemented by this specification.

2.46.2 Type and Rating

Except where specified otherwise or economically justified, all a.c. motors shall be of the constant speed, cage induction type with windings adequately braced for direct-on-line starting at the rated voltage. They shall

be suitable for control by either circuit breaker or fused contactor.

Motors shall be continuously rated, Duty Type S1. Exceptions shall be permitted only when the intermittent or short time duty cycle can be accurately defined by the Bidder.

Three phase a.c. motors shall be rated for the voltages specified elsewhere in the Specification. The minimum rated output of HV motors shall comply with IEC 34-1. The maximum rated output of LV motors shall not exceed 150 kW, except where approved by the Engineer.

2.46.3 Insulation

Motors shall be insulated with materials complying with IEC 85. All motors shall have Class F insulation but the temperature rise shall not exceed the limits applicable to Class B.

2.46.4 Conditions of Operation

A.C. motors shall be capable of continuous operation under the service conditions within the Zone A voltage and frequency variations specified in IEC 34-1 Figure 13 or as covered in Clause 4.1 whichever is the most onerous.

Unless otherwise specified, the motors shall be capable of continued operation at 75% rated voltage and rated frequency for a period of 5 minutes without injurious heating. In the event of loss of supply, all motors shall be suitable for restarting against the full residual voltage in the motor winding during motor run-down.

2.46.5 Starting Performance

Unless otherwise specified or required, cage induction motors up to and including 40 kW shall have a starting performance better than or equal to Design N in accordance with IEC 34 (External inertias for 50 and 60 Hz motors shall be in accordance with BS 4999 Part 112). Cage induction motors above 40 kW shall have a starting performance better or equal to Design D in accordance with BS 4999 Part 112. The starting current at full voltage shall not exceed 6 times full load current.

The starting torque at 80% voltage shall be adequate for starting the driven load under the most arduous conditions, such as open fan vane or open pump discharge valve. The accelerating torque at any speed and 80% rated voltage shall be not less than 10% of motor rated torque. In any event the motor starting torque at 100% rated voltage, and at all speeds between standstill and the speed at which breakdown torque occurs, shall be not less than 1.7 times the torque obtained from a load curve which varies as the square of the speed and is equal to 100% motor rated torque at rated

speed.

The margins between the torques of the motors and driven plant shall include suitable allowances for impeller wear, fouling etc. during the life of the plant.

Electric motors shall be suitable for two successive starts with the motor already at full load working temperature, subject to the motor being permitted to decelerate to rest under operating conditions between successive starts.

After a cooling period of 30 minutes at rest another starting sequence of two successive starts shall be permissible.

2.46.6 Bearings

The type of bearings used in the motor shall be fully compatible with those used in the driven equipment.

The type of bearing, bearing numbers and regressing interval shall be stamped on each motor rating plate.

Bearings shall comply with the applicable ISO standards.

Bearings shall be designed to exclude the ingress of dust and water and sealed to prevent leakage of lubricant along the shaft.

2.46.7 Enclosures and Methods of Cooling

The degree of enclosure protection for motors shall be as follows unless otherwise specifically approved by the Engineer:

- IP54 for indoor locations not subject to hosing.
- Not less than IP 55W for outdoor locations, and indoor locations subject to hosing.
- Where motors are exposed to solar radiation, sunshades shall be fitted, if required by the manufacturer to meet his guarantees.

The cooling classification for motors shall be as follows unless otherwise specifically approved by the Engineer:

- IC4AlA1 or IC5AIA1 for LV motors, or IC4AIAO for small power LV motors.

- IC4AlAl, IC5AlAI, IC6A1A1 or IC7AlW7 for HV motors.

- Ferrous metals should be used for the frames and end shields of all ratings of motors.

Aluminium and its alloys shall only be used when the manufacturer can demonstrate that such materials are entirely suitable for the particular application at its installation location.

Fans of identical motors shall be interchangeable without affecting motor balance.

2.46.8 Anti-condensation Heaters

To minimise condensation in all outdoor 400V and intermittently used 400 V motors when out of service, heaters of an approved type and rating, suitable for operation from a 230 V a.c. single phase supply, shall be fitted inside the lower half of the stator frame.

The control of anti-condensation heaters shall be so arranged that they are normally energised when the motor is not running.

2.46.9 Terminals and Terminal Boxes

Winding terminations shall generally comply with BS 4999 Part 145. Separate non-compound filled, terminal boxes shall be provided for each of the following, as applicable:

(a) Main (line) connections.

(b) Star point connections.

(c) Anti-condensation heater connections.

(d) Instrumentation and alarm devices.

All terminal boxes with the cables terminated shall have an enclosure classification not less than that of the motor itself. All terminal boxes shall be of an adequate size for the satisfactory termination of the cable(s) required or specified, including all applicable termination components.

All HV terminal boxes shall be provided with a desiccant indicator, externally sealed.

Terminals and terminal leads shall be to approval and shall be substantially designed for connection to a system having the symmetrical short circuit rating of the source switchboard, as limited by fuses, where applicable.

The clearances and creepage distances shall apply also to insulated terminals and connectors.

Porcelain terminal bushings and insulators shall not be used.

Main and star point terminal boxes of HV motors shall be of steel. Cast iron

may only be used for LV motor terminal boxes and auxiliary terminal boxes.

Star point terminal boxes shall only be provided where required to accommodate neutral end current transformers and shall be positioned opposite the main terminal box.

Main HV terminal boxes at voltages exceeding 7.2 kV (Um) shall be of a type which restricts internal faults to earth faults only. Where pressure relief terminal boxes are used, they shall be designed to relieve the products of an internal fault safely to the outside, and not into the interior of the motor.

Provision shall be made for earthing the cable armour and the cable insulation screens, where applicable, in accordance with the cable termination method being used.

In auxiliary cable boxes either stud terminals or clamp terminals shall be provided.

The anti-condensation heater terminal box shall have a warning label adjacent to it, stating "Motor heater - terminals live".

2.46.10 Earth Terminal

All motors shall be provided with a means of earthing the frame, which shall be to the approval of the Engineer.

2.46.11 D.C. Motors

D.C. motors which are to operate from batteries shall be capable of operating under the service conditions at any voltage in the range of 80% to 110% of the nominal value.

Motors of the constant speed type shall be designed to operate with a permanent series resistor of suitable rating and with a contactor such that starters with tagged resistors are not required.

All d.c. motors shall be provided with brushgear which does not require to be moved to suit load conditions.

Motors connected to rectifier equipment shall meet the conditions of supply voltage and frequency specified for a.c. motors. Where necessary, rectifier equipment shall be fitted with a current limiting device.

2.47 MOTOR STARTERS AND CONTACTORS FOR SEPARATE MOUNTING

In special cases for motors below 30 kW, and non-essential non-plant auxiliaries, such as roller shutter doors, and where approved by the

Engineer, separately mounted starters for motors may be provided. Each such motor starter shall be equipped with two or three pole control gear, as appropriate, for direct-on-line starting and shall be complete with a fully shrouded lockable isolating switch, mechanically interlocked with the means of access.

All starters shall be supplied by one manufacturer, except where otherwise approved by the Engineer.

Contactors shall be of robust design and shall comply with IEC 60947.

All contactors and their associated apparatus for minor motors shall be capable of operating without overheating for all specified motor operating conditions, and including for a period of five minutes at normal frequency if the supply voltage falls to 80% of nominal voltage.

For motors up to 30kW rating motor starters shall be provided with direct connected thermal overload and phase failure industrial pattern protection tripping devices, integral with the motor contactor. Phase failure protection shall operate with out-of-balance currents not exceeding 85% of motor full load current. Separate contacts for a remote trip alarm shall be provided, and connected up if required.

For motors above 30kW starters shall not be wall mounted but included in a switchboard, except with the approval of the Engineer. For such circuits motor protection relays with a more accurate and easily adjustable overload setting shall be used, which are sensitive to out-of-balance currents not exceeding 20% of full load, and shall include instantaneous earth fault elements. Alternatively, instantaneous earth fault protection may be incorporated in the motor circuit breaker. The earth fault protection shall not operate for unbalanced current surges during motor starting.

2.48 PUSHBUTTONS AND SEPARATELY MOUNTED PUSHBUTTON STATIONS

Pushbuttons, which may be of the illuminated or non illuminated type, shall be shrouded or well recessed in their housings in such a way as to minimise the risk of inadvertent operation.

In instances where "enable" pushbuttons are required they shall be electrically interlocked with the normal control such that deliberate operation of the "enable" push-button is required before the normal control can take place.

The colour of pushbuttons shall be as follows:

- When mounted on pushbutton stations adjacent to running plant the stop button shall be coloured red and the start button coloured green.

- When mounted on the front of the contactor panel the stop button shall

be coloured red and the start button coloured green.

- When mounted on panels or desks with adjacent indication lights both buttons shall be coloured black, unless required otherwise by the Engineer.

Loose pushbutton stations, unless supplied as weatherproof free standing enclosures, shall be of the metalclad weatherproof type suitable for wall or bracket mounting with a minimum enclosure classification of IP55. All outdoor mounted pushbutton stations shall incorporate a protective cover or guard (e.g. toughened glass door) to prevent inadvertent operation.

Control stations shall be clearly labelled showing the duty or drive to which they are applicable. Location of ammeters shall be agreed with the Engineer.

Pushbuttons used on covered desks, panels etc. may of necessity require to be of special types (e.g. miniature, illuminated). The specifications and requirements for these special pushbuttons shall be agreed with the Engineer.

Emergency stop pushbuttons shall be provided adjacent to all motors and machinery with exposed moving parts, couplings etc. to prevent danger, and on main and local control panels. These pushbuttons shall have a large "mushroom" head, be coloured red and incorporate a protective cover or guard to avoid accidental operation. These buttons shall automatically lock in the depressed position, requiring twist or key resetting. Contacts shall be provided to cause tripping of the associated circuit, prevent restart of the circuit and bring up an alarm in the Central Control Room.

Stop pushbuttons mounted local to motors shall trip the associated circuit breaker or contactor regardless of the control position selected.

The contacts of all pushbuttons shall be shrouded to minimise the ingress of dust, and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

2.49 MINIATURE CIRCUIT BREAKERS, FUSES AND LINKS

Facilities shall be provided for protection and isolation of circuits associated with protection, control and instruments. They shall be of approved type and grouped, as far as possible, according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Facilities shall be provided to enable the control circuits for any circuit-breaker to be individually isolated for maintenance purposes.

Facilities for protection and isolation of control and tripping circuits are preferably to be mounted on the outside of control panels in approved

positions.

All fuses shall incorporate HRC cartridges to BS 88 or IEC 60269.

Fuse holders shall be designed to lock the cartridges firmly into position without the use of screw clamping devices.

Miniature circuit-breakers (MCB's) shall comply with IEC 60898.

Where MCB's are used on control, protection and alarm supplies, tripping shall cause an alarm to be displayed.

2.50 EARTHING AND BONDING

The main earthing conductors for connection to all electrical equipment, cables, motors, panels, etc., shall be provided for connection to the main earthing system.

All non-current carrying metal parts of electrical equipment shall be bonded to an earth terminal or terminals mounted on the equipment and readily accessible.

All equipment terminals provided for an external earth connection shall be identified by indelible means unless such terminals are directly and visibly mounted on metallic equipment frames or earth bars, when such marking may be omitted.

Identification marks for earth terminals shall comprise the colours green/yellow in combination or a reproduction of the symbol no. 5019 in IEC 60417.

Assemblies containing electrical equipment, including switchboards, control boards and control desks, shall be provided with a separate copper earth bar running the length of the assembly. All metal parts and the earth terminal or terminals shall be bonded to this earth bar. Earthing connections shall not depend upon the bolting of steel/steel joints between adjacent panels or cubicles.

Earth bars shall be of adequate size and suitably supported and braced to carry the rated short circuit current for the associated electrical circuits for the rated short-circuit current duration, without damage or excessive heating likely to damage joints, associated or adjacent components.

Switchgear and control gear assemblies shall be provided with two or more earth terminals unless otherwise specified. The copper earth bar shall be sized to withstand the maximum system earth fault current for three seconds without deterioration.

The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus shall be such as to comply

with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall be a minimum of 100 mm2 cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and also providing this size is not less than the size of the largest incoming power supply conductor.

The metal cases of all instruments, relays and the like shall be connected to the panel earth bars by copper conductors of not less than 1.5 mm2 cross-sectional area, or by other means to the approval of the Engineer.

If the plant contains electronic equipment which is vulnerable to possible conductive interference, or if the equipment generates electrical noise, which could interfere with other plant or equipment, then separate earths may be supplied and the actual means of interconnecting with the station earth system shall be agreed with the Engineer.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 3

HV SWITCHGEAR AND NEUTRAL EARTHING EQUIPMENT

SECTION 3

HV SWITCHGEAR AND NEUTRAL EARTHING EQUIPMENT

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SECTION 3

HV SWITCHGEAR AND NEUTRAL EARTHING EQUIPMENT

3.1 SCOPE

These clauses describe the General Technical Requirements for outdoor, open terminal circuit breakers & general switchyard equipment, and shall be read in conjunction with the Project Requirements, Schedules and Drawings in the specification.

The Bidder shall demonstrate that the switchgear has been designed, built and installed in accordance with the relevant international standards and the specification. It shall also operate and perform on a site in accordance with the requirements of the specification and in the environment defined therein.

The design shall be proven by the submission of test certificates at the time of Bidding covering all specified tests deemed to be pertinent to the plant and to the conditions in which it will operate.

The requirement for switchgear spares, tools and appliances, including test, maintenance and handling equipment shall be as stated in the Bid document. All devices necessary for operation and earthing shall be provided within the Contract Price.

Installation, testing and Commissioning of all switchgears shall be done by the Switchgear Engineer(s) of the switchgear(s) manufacturer(s).

3.2 REFERENCES

3.2.1 IEC Standards

IEC 60060	High Voltage test techniques
IEC 60071	Insulation Co-ordination
IEC 60099	Surge arresters
IEC 60044-1	Instrument Transformer-Part 1: Current transformers
IEC 60044-2,	Instrument Transformer-Part 2: Voltage transformers
IEC 60044-5	Instrument Transformer-Part 5: Capacitive Voltage transformers
IEC 60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC 60305	Insulators for overhead lines with a nominal voltage above 1000V - Ceramic or glass insulator units for ac systems - Characteristics of insulator units of the cap and pin type.

IEC 60376	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IEC 60383	Insulators for overhead lines with a nominal voltage above 1000V
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V
IEC 62271-1	HV switchgear and controlgear-part1: common specifications
IEC 62271-100	HV switchgear and controlgear –part100: AC circuit breakers
IEC 62271-102	HV switchgear and controlgear-part102: AC disconnectors and earthing switches
IEC 62271-200	A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

3.2.2 British Standards

BS 7884	Specifications for hard-drawn copper and copper cadmium conductors for overhead power transmission purposes
BS EN 60383-2	Insulators for overhead lines with voltage greater than 1000V.
BS 159	Specifications for HV busbars and busbar connections
BS 215S	Specifications for aluminium conductors for overhead transmission
BS EN 13600	Specifications for high conductivity copper tubes for electrical purposes
BS 2898	Specifications for wrought aluminium for electrical purposes. Strip with drawn or rolled edges.
BS 3288	Insulator and conductor fittings for overhead power lines.
BS 3938	Current Transformers
BS 6651	Lightning Protection
BS 7354	Code of practice for design of HV open terminal stations.

3.3 DESIGN PRINCIPLES

3.3.1 General Requirement

The normal operations will be effected from the Naional Load Dispatching Centre (NLDC) at Rampura. The bidder shall take into consideration the

unmanned operation of the substation in his design (No operators are necessary in the new substation control rooms).

Control facilities shall be simple and clearly designated with the respective function and instructions on operation and maintenance shall be unambiguous.

The following provisions shall be made for control and indications:-

Control cubicle local to equipment - control of circuit breakers, disconnectors and earthing switches where power operated, complete with electrical indications, mimic diagram, gauges and alarm annunciator.

Remote panel in the control room on each Substation Site - control of circuit breakers, disconnectors and line side earthing switches where power operated with position indication in each instance.

Supervisory control from NLDC-provision of control of circuit breakers and disconnectors switches where power operated, with position indication in each instance.

All necessary local/remote and remote/supervisory control relays, interposing relays and selector switches are to be provided as part of this Contract.

Circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle. In case of labels not visible when standing on the floor, additional name plate shall be fixed at a suitable location.

A single line diagram shall be marked along each bay showing the location of all items of switchgear.

In the event of leakage from any compartment, equipment shall withstand rated voltage with SF6 at atmospheric pressure. The insulation levels shall be able to withstand basic test voltages in accordance with the relevant standards for Synchronising Operation for Breakers.

Busbar connections and enclosures shall be designed to absorb the effects of thermal expansion without application of stress to the supporting structure.

3.3.2 Availability for Maintenance, Repair, Extensions, Testing

Maintenance, Repair or Extension (MRE) and HV Testing on one busbar with directly connected apparatues shall be possible with the other busbar in normal operation.

MRE Testing on one swithgear bay shall be possible with all other switchgear bays in normal operation on one busbar.

MRE Testing on/of buscoupler bay shall be possible with one busbar at the time in normal operation and all switchgear bays in normal operation.

Maintenance access to each module shall be possible without necessitating the outage of adjacent modules.

3.4 OUTDOOR HV SWITCHGEAR

3.4.1 Switchgear - Design and Performance

The switchgear shall be suitable for outdoor location and capable of continuous operation under the climatic conditions existing on site. It shall be designed to comply with this Specification and relevant IEC and British Standards where applicable. Deviations from these Specifications and Standards shall be stated in Schedule F of Departures.

In all cases the ancillary plant necessary to complete installation of the equipment shall be included in the Contract. The disposition of plant in any substation is to be such that the operation of any item of plant under the specified service conditions, shall in no way create a condition that could adversely affect the performance of adjacent circuit breakers or any associated equipment.

The Bidder is to ensure that the complete substation installation will satisfy the requirements of this Specification and the appropriate Standards in respect of insulation, fault levels, mechanical stress etc., and any additional equipment found to be necessary to meet these requirements shall be deemed to have been included in the Contract Price.

The layout and design of plant and equipment on substation sites shall make provision for the future extensions shown on the layout drawings and shall provide for ready access for operation, maintenance and extension whilst the remaining sections of equipment are alive. Electrical clearances provided between isolated equipment and nearest live metal work shall not be less than the distance data as mentioned in sub-clause 1.2.3 of Section -1 of this specification (vol 2 of 3). Insulation creepage distances shall not be less than 25mm per kV rated voltage between phases.

The Bidder shall be responsible for ensuring that insulation co-ordination in accordance with recommendation of IEC 60071 is achieved. Dynamic and temporary over voltages shall be assumed to be in accordance with normally accepted IEC levels and subject to approval of the Engineer.

3.4.2 Current Ratings

Every current-carrying part of the switchgear including current transformers, busbars, connections, contacts and joints shall be capable of carrying its specified rated current at rated frequency continuously, and in no part shall its temperature rise exceed that specified in relevant standards.

Every part of the switchgear shall also withstand, without mechanical or thermal damage, the instantaneous peak currents and rated short time current pertaining to the rated breaking capacity of the circuit-breaker.

3.4.3 Corona

Equipment shall be designed so as to minimise corona or other electrical discharge and radio interference. The Bidder is to confirm and ensure adequacy of design in terms of corona performance. Ion current density shall be less than 20 na/sqm at ground level. The Bidder shall furnish all calculations and documents in support of the above during detailed engineering. Tests for corona and radio interference shall be carried out by the Bidder at his Works and on Site as required by the Engineer. The requirements regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. In case the connector is not available then equivalent connector may be used. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of Work.

3.4.4 Local, Remote and Supervisory Control

Circuit breakers and motorised disconnectors shall be electrically controlled locally, remotely and by supervisory telecontrol. Position indication of these devices shall be provided on their operating mechanisms and the Bidder shall include the supply and fitting of the necessary auxiliary switches for remote position indication.

For supervisory telecontrol, the interface between the telecontrol control equipment and the control equipment being provided under this Contract shall be as specified in Section 10.

3.4.5 HVAC Circuit-Breakers

3.4.5.1 General

The circuit breakers and accessories shall conform to relevant IEC: 62271-100, IEC: 60694 and other relevant IEC standards except to the extent explicitly modified in the Specification.

The circuit breakers shall be sulphur hexafluoride (SF6) type only. The 36kV circuit breakers shall be vacuum type only.

The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure for CB and control cabinets, their foundation bolts and all other circuit breakers

accessories required for carrying out all the functions the CB is required to perform. All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided. The support structure of circuit breaker as well as that of control cabinet shall be hot dip galvanised. All other parts shall be painted as per approved shade.

3.4.5.2 Operating Duty and Performance

a) The circuit breaker shall be rated for the switching, interrupting and current carrying duty imposed upon them in their intended application.

b) The total interrupting time shall be 2 cycles or less (5 cycles or less in case of 36kV CB) from energization of trip circuit of the circuit breaker to the extinction of the arc. The total closing time shall be less than 150 msec from energization of closing circuit of the circuit breaker to closing of the breaker contacts. The operating duty cycle shall be 0 - 0.3 sec - CO - 3 min - CO, with no de-rating for the first re-closure between operations over the voltage range from nominal to rated maximum voltage and from zero to the maximum rated interrupting current without the necessity of intermediate maintenance. The circuit breakers shall be capable of withstanding the transient recovery voltage as per IEC-62271 (values to be determined by the Bidder).

c) The circuit breaker shall be designed for M2C2 class (M2C1 in case of 36kV CB) as per IEC 62271 under all duty conditions.

d) The circuit breaker shall meet the duty requirements for any type of fault or fault location and for line switching when used on a 420k420kV, 245kV & 145kV effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

e) The circuit breaker shall be capable of performing their required duty as per application including

i) Interrupting steady and transient magnetizing current of transformers of specified ratings or as the case may be.

ii) Interrupting line charging current as per IEC.

iii) Clearing short line faults (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iv) Clearing bus faults on 400 kV, 230KV and 132 kV AC switchyard.

v) Clearing faults as second-in-line breaker in the event of failure of main breaker.

vi) Breaking small inductive currents of 0.5 A to 10 A without switching over voltage exceeding 2.3 p.u.

vii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

viii) Breaking large capacitive currents considering the largest bank/sub-bank of filters under most onerous condition causing maximum stress to the breaker. The breakers shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energization with trapped charges. The breakers shall also withstand the voltages specified.

f) The total break time as specified shall not be exceeded under any of the following duties:

i) Test duties 1,2,3,4,5 (TRV as per IEC:62271-100)

ii) Short line fault L75, L90 (TRV as per IEC:62271-100)

g) The Bidder may please note that the total break time of the breaker shall not be exceeded under any duty conditions specified.

3.4.5.3 Constructional Features

The features and constructional details of the circuit breaker shall be in accordance with requirements stated hereunder:

a) The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 p.u. across the breaker continuously).

b) If multi break interrupters are used, these shall be so designed and augmented that a uniform voltage distribution is developed across them. Calculations/test reports in support of the same shall be furnished by the Bidder. The thermal and voltage withstand capabilities of the grading elements shall be adequate for the service conditions and duty specified.

c) The SF6 circuit breaker shall meet the following additional requirements :

i) The circuit breakers shall be of single pressure buffer type. The design and construction of the circuit breaker shall be such that neither SF6 gas shall leak to atmosphere and nor moisture shall enter in the breaker. There shall not be any condensation of SF6 gas on the internal insulating surface of the circuit breakers.

ii) All gasket surfaces shall be smooth, straight and reinforced, if necessary, to minimize distortion and to make a tight seal. The operation rod connecting the operating mechanism to the arc chamber shall have adequate seals. The SF6 gas leakage should not exceed 1% per year. In case the leakage under specified conditions is more

than 1% after one year of commissioning of the circuit breaker, the manufacturer shall have to supply free of cost, the total make up gas requirement for subsequent ten(10) years based on actual leakage observed during first year of operation after commissioning. In the interrupter assembly there shall be an absorbing product box to minimize the effects of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas as well as its decomposition products.

iii) Each pole shall form an enclosure filled with SF6 gas independent of two other poles and the SF6 density of each pole shall be monitored. The SF6 gas density monitor shall be provided on each of the individual poles.

iv) The gas density in the SF6 circuit breaker shall never be less than the minimum required insulating density of SF6. Gas density monitoring equipment with two level alarms shall be provided.

v) The dial type SF6 gas density monitor shall be adequately temperature compensated to model the density changes due to variations in ambient temperature within the body of the circuit breaker as a whole. The density monitor shall meet the following requirements:

It shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by using suitable interlocked non-return valve coupling.

It shall damp the pressure pulsation while filling the gas so that the flickering of the pressure switch contacts does not take place. Filling of SF6 gas shall not be performed in the closed position of breaker.

vi) Suitable means for pressure relief shall be provided in the gas chamber of circuit breaker to avoid the damages or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electric fault arcs. The position of vents, diaphragms and pressure relief devices shall be so arranged to minimize danger to the operators in the event of gas or vapour escaping under pressure.

vii) Each circuit breaker shall be capable of with standing a vacuum of 8 mill bars without distortion or failure of any parts.

viii) Sufficient SF6 gas including that required for gas analysis during filling shall be provided to fill all the circuit breakers installed. In addition 20% of total gas requirement shall be supplied at respective station, in separate cylinders as spare requirement for Employer’s later use.

d) Provision shall be made for attaching an operational analyser after

installation at site to record contact travel, and making measurement of operating timing, synchronization of contacts in one pole and dynamic contact resistance measurement.

3.4.5.4 Sulphur Hexafluoride Gas (SF6 Gas)

a) The SF6 gas shall comply with IEC-60376, 376A and 376B and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas shall be shipped and stored at site shall comply with requirements of relevant IEC/ British standards and regulations.

c) SF6 gas shall be tested for purity, dew point, break down voltage, air, hydrolysable fluorides and water content as per IEC-60376, 376A and 376B and test certificates shall be furnished to Employer indicating all the tests as per IEC- 60376 for each lot of SF6 gas. Gas bottles shall be tested for leakage after receipt at site.

3.4.5.5 Insulators

a) The porcelain of the insulators shall conform to the requirements stipulated under Clause 3.4.11 of this section.

b) The mechanical characteristics of insulators shall match with the requirements specified.

c) All insulators shall conform to IEC-61264(for pressurised hollow column insulators) and IEC-233(for others). All routine and sample tests shall be conducted on the hollow column insulators as per these standards with requirements and procedures modified as under:

   i) Pressure test as a routine test

   ii) Bending load test as a routine test

   iii) Bending load test as a sample test on each lot.

   iv) Burst pressure test as a sample test on each lot.

   v) In addition to the above, ultrasonic test shall be carried out as additional routine test.

d) Jointed porcelain shall not be accepted.

3.4.5.6 Mandatory Maintenance Equipment

The Bidder shall supply the following mandatory maintenance equipment.

a) SF6 gas filtering, drying, storage, filling and evacuation plant. This shall include all the necessary devices for measurement of purity, moisture content, etc. of SF6 gas. The plant shall be complete with accessories and fittings so that SF6 gas from the breaker can be directly filled in the plant storage reservoir. The SF6 gas handling plants shall comply with the following requirements:

   i) The plant shall be complete with all the necessary pipes, couplings, flexible tubes and valves for filling or evacuating SF6 gas.

   ii) The design and construction of the plant shall be such that leakage of SF6 gas is minimum.

   iii) Instruments for dew point measurement and air content measurement shall be provided.

   iv) Equipment shall have built in calibration facility.

b) SF6 gas leak detector:

   The detector shall be free from induced voltage effects. The sensing probe shall be such that it can reach all the points on the breaker where leakage may be required to be sensed.

c) Operational analyzer:

   The operational analyzer shall meet the following requirements:

   i) The analyzer shall be suitable for outdoor operation and shielded against induced charges.

   ii) Operational analyzer shall be one complete system which once installed should record all the parameters as laid down in subsequent clauses.

   iii) The analyzer should be able to record breaker contact movement during opening, closing, auto reclosing and make break operation as well as the speed of contacts at various stages of operation, travel of contacts, opening time, closing time, make break time, dynamic contact resistance measurements etc.

   iv) The analyzer shall have provisions for recording simultaneously at least 12 different functions of the circuit breaker. All necessary transducers, cables, and attachments required for the breaker shall be supplied with the analyzer.

3.4.5.7 Operating Mechanism and Control

General Requirements

a) Circuit breaker shall be operated by spring charged mechanism, or a combination of hydraulic and spring mechanism. The 36kV vacuum circuit breakers shall be operated by motor spring stored energy mechanism only. The mechanism shall be housed in a weather proof and dust proof control cabinet. Circuit Breakers with Hydraulic mechanism only is not acceptable.

b) The operating mechanism shall be strong, rigid, not subject to rebound and shall be readily accessible for maintenance for a man standing on ground.

c) The operating mechanism shall be suitable for high speed reclosing and other duties specified. During re-closing operation the breaker operating mechanism and control shall have capability to close fully and re-open if required. The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

d) The mechanism shall be such that the failure of any auxiliary spring shall not revent tripping and shall not cause trip or closing operation of the power operating devices.

e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it shall be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet.

f) Working parts of the mechanism shall be of corrosion resisting material. Bearings which require grease shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

g) The Bidder shall provide software based condition based monitoring for life assessment and maintenance of the Circuit Breaker.

Control

a) The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

b) Each breaker pole shall be provided with two (2) independent tripping circuits and coils each being connected to different set of protective relays.

c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switches and close and trip push buttons shall be provided in the

breaker central control cabinet.

d) The trip coils shall be suitable for trip circuit supervision. During both open and close position of breaker. The trip circuit supervision relay would be provided.

e) Closing coil & associated circuits shall operate correctly at all values of voltages between 85% and 110 % of rated voltage. Shunt trip coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage.

f) Density meter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for tripping and closing circuits. If contacts are not suitably rated and multiplying relays/contactors are used for density, monitor and pressure switch contact multiplication then fail safe logic/schemes shall be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciation and operation lockout in case of failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit breaker.

g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

Spring Operated Mechanism

a) Spring operated mechanism shall be complete with motor, opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor OCO operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing the breaker they shall be automatically charged for the next operation and an indication of this shall be provided in the local control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

3.4.5.8 Support Structures

a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to a minimum.

b) If required, the Bidder shall provide suitable platform with steps on both sides of the circuit breaker for easy accessibility for monitoring the density/pressure of gas.

3.4.5.9 Terminal Pads

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium. The terminal pad shall have protective covers which shall be removed before interconnections.

3.4.5.10 Fittings and Accessories

Following is a partial list of some of the major fittings and accessories to be furnished by Bidder in the central control cabinet. Number and exact location of these parts shall be indicated in the drawing.

a) Cable glands, lugs, ferrules, etc.

b) Local/Remote changeover Switch

c) Open/Close buttons and Operation counter

d) Pressure gauges

e) Control switches to cut off control power supply

f) MCBs/MCCBs as required

g) Anti-pumping relay

h) DC auxiliary power supervision relay.

i) Pole discrepancy relay

j) Rating and diagram plate in accordance with IEC

k) The number of terminals provided shall be adequate to wire out all contacts and control circuits after leaving 24 terminals as spare for future use.

3.4.5.11 Tests

Type Tests

Each type of circuit breaker along with its operating mechanism shall conform to the type tests as per IEC: 62271-100.

Routine Tests

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.

Site Tests

All routine tests except dielectrics shall be repeated on the completely assembled breaker at site.

3.4.5.12 Technical Parameters

The Bidder shall determine the technical parameters of breakers to be provided. Refer to Appendix-A1 of Schedule-A of volume 3 of 3 (Schedule of Requirements) for the technical parameters of the circuit breakers generally used by the Employer and are given for the information of the Bidder.

3.4.6 Disconnectors and Earth Switches

3.4.6.1 General

The disconnectors (isolators), earth (ground) switches and accessories shall conform in general to IEC-62271-102 except to the extent explicitly modified in the Specification.

The isolators shall be electrically ganged only. Earth switch(es) shall be provided on isolators wherever possible, otherwise free standing earth switch shall be provided.

Complete isolator with all the necessary items for successful operation shall be supplied including, but not limited to, one central (common) control cabinet for each 3 phase isolator/earth switch and one control cabinet for each pole with all the required electrical devices mounted therein, complete with base frame, linkages, complete operating mechanism etc.

3.4.6.2 Operating Duty and Performance

Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

The earth switch shall be capable of discharging trapped charges.

The isolators shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

The isolator shall be capable of making/breaking magnetizing current of at least 0.7A at 0.15 power factor and capacitive current of at least 0.7A at 0.15 power factor.

The terminals of the isolator and earth switch(es) shall be able to withstand the total forces including wind loading and electrodynamics forces on the attached conductor without impairing reliability or current carrying capacity in accordance with IEC-62271-102.

The earth switch should be able to carry the same fault current as the main blades of the isolator and shall withstand dynamic stresses.

3.4.6.3 Constructional Features

The main features and constructional details of isolators with earth switches and other accessories shall be in accordance with requirements stated hereunder:

General

Design of the isolator shall be such as to permit addition of earth switches at a future date. It shall be possible to interchange position of earth switch to either side of pole even at site.

Contacts

a) The isolator shall be provided with high pressure current carrying contacts made of copper on the hinge and jaw ends and all contact surfaces shall be silver plated. The thickness of silver plating shall not be less than 25 microns. The contacts shall be accurately machined and self aligned.

b) The contacts shall be of sufficient pressure to ensure effective contact and low contact resistance throughout the life of the switch. The contact pressure shall not exceed a safe working value for the materials in contact and shall cause no abrasion or scarring of the contacts.

c) The contacts shall be of self-aligning and self- cleaning type and shall be so designed that binding can not occur after remaining closed for prolonged periods.

d) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and springs shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator/earth switch. Each contact or pair of contacts shall be independently

sprung so that full pressure is maintained on all contacts at all times. Provision shall be made to adjust the contact pressure.

e) Contact springs shall not carry any current and shall not loose their characteristics due to heating effects.

f) The isolator shall be so designed that when operated within their specified rating, the temperature of each part shall be limited to values consistent with a long life for the material used. The temperatures shall not exceed the permissible limits given in IEC-62271-102 under specified ambient conditions.

Base

a) Each single pole of the isolator/earth switch shall be provided with a completely galvanized steel base. The base shall be rigid and self supporting and shall require no guying or cross bracing between phases.

b) The frame of each isolator and earthing switch shall be provided with two ground terminals for connection to the ground mat.

Blades

a) All metal parts shall be of non-rusting and non corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities when provided on current carrying parts shall be made of copper silicon alloy or equivalent. The bolts or pins used in current carrying parts shall be made of nonferrous and non-corroding material. All castings except current carrying parts shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces. Where this is impracticable adequate corona shields shall be provided. Corona shields/rings etc. shall be made up of aluminium/aluminium alloy.

c) The isolator/earth switch shall be so constructed that the switch blade shall be locked in the open/close position and shall not fall to the closed/opened position in case the operating shaft gets disconnected.

d) The isolator/earth switch including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

e) The isolator/earth switch shall be designed such that no lubrication of any

part is required except at very infrequent intervals.

f) The switch blade contact shall enter into the counter contact even if it is misaligned by 45 mm in any direction.

Insulator

a) The insulator shall conform to IEC-60168. The porcelain of the insulator shall have minimum cantilever strength of 800kg, however, the final strength shall be as per short circuit force calculation during detail Engineering. The insulators shall be of solid core type.

b) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

c) The insulators shall be so arranged that leakage current shall pass to earth and not between terminals of same pole or between phases.

Earth Switches

a) Wherever earth switch(es) are specified these shall include the complete operating mechanism and auxiliary contacts.

b) The earth switch shall form an integral part of the isolator and shall be mounted on the base frame of the isolator, whenever possible.

c) The earth switch shall be only locally (motor) operated.

d) The earth switch(es) shall be constructionally interlocked, wherever provided with the isolator, so that the earth switch(es) can be operated only when the isolator is open and vice versa. The constructional interlocks shall be a built in feature in construction of isolator and shall be in addition to the electrical and mechanical interlock provided in the operating mechanism.

e) In addition to the constructional interlock, isolator and earth switch(es) shall have provision to prevent their electrical and manual operation unless the interlocking conditions are met. All these interlocks shall be of fail-safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from dc supply and within a variation range as stipulated.

f) Each earth switch shall be provided with flexible copper/aluminium braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through switch connection shall not be accepted.

g) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts including in the course of its movement between Close and Open position.

Operating Mechanism

a) The isolators and earth switches shall be ac motor operated.

b) Limit switch for control shall be fitted on the isolator/earth switch shaft, within the cabinet to sense and ensure the open and close positions of the isolator and earth switch.

c) After final adjustment has been made it shall not be possible for any part of the mechanism to be displaced at any point in the travel sufficient enough to allow improper functioning of the isolator/earth switch whenever it is opened or closed at any speed. All holes in cranks, linkage etc. having moving pins shall be drilled to accurately fit so as to maintain the minimum of slack and loose motion in the entire mechanism.

d) A "Local/Remote" selector switch and a set of "Open/Close" push buttons shall be provided in the control cabinet of the isolator to permit its operation. A "Local/Remote" selector switch and "Open/Close" push buttons shall also be provided in central control cabinet to permit simultaneous operation of all three phase.

e) Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

f) Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop rapidly when motor supplies are switched off.

g) Each motor operated mechanism shall be subjected to blocked rotor test.

3.4.6.4 Operation

a) Isolator and earthing switch shall have one drive for main blade and one drive for earthing switch. The operating mechanism of the three poles shall be well synchronized and interlocked.

b) The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock nut after an adjustment has been made. The isolator & earth switches shall be provided with "over centre" device in the operating mechanism to prevent accidental opening by wind or vibration or short circuit forces or movement of the support structures.

c) Each isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator or earth switch with

ease in one movement while standing at ground level. The manual operating handle shall have provision for padlocking. The operating handle shall be located at 1000 mm from the base of isolator support structure.

d) The isolator/earth switch shall be provided with positive continuous control throughout the entire cycle of operation. The operating rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for closing. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator/earth switch. Wherever supported the operating rods shall be provided with bearings on either ends. The operating rods shall be provided with suitable universal couplings to account for any angular misalignment.

e) The transmission of motion from the electrical operating mechanism shall be by rigid members. It is required that, in the event of over torque of the switch mechanism, no part of the main switch mechanism shall bend, twist or shear and so allow the auxiliary switch contacts to operate erroneously.

f) All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rustproof.

g) The position of movable contact system (main blades) of each of the isolators and earth switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the isolators and earth switch. The indicator shall be of metal and shall be visible from operating level.

h) Signalling of closed position shall not take place unless it is certain that the movable contacts shall reach a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signalling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is at least 80% of the isolating distance.

i) Counter balance spring if required shall be provided for counter balancing the isolator and earth switch to prevent impact at the end of the travel both on opening and closing. The spring shall be made of non rusting type alloy.

3.4.6.5 Tests

Each type of isolator and earth switch along with their operating mechanism shall be subjected to the type tests and routine tests in accordance with IEC-62271-102. The radio interference voltage and corona extinction voltage test shall also be conducted as type test.

3.4.6.6 Technical Parameters

The Bidder shall determine the technical parameters of the isolators/earth switches. Refer to Appendix-A1 of Schedule-A of volume 3 of 3 (Schedule of Requirements) for the technical parameters of the isolators/Earthing switch generally used by the Employer and are given for the information of the Bidder.

3.4.7 Instrument Transformers

3.4.7.1 General

The AC Instrument Transformers and accessories shall conform to the latest version of IEC 60044. The instrument transformers provided for control, metering and protective relaying functions shall have accuracy ratings and burden capabilities adequate to provide their designated functions within the overall accuracy requirements of the systems.

3.4.7.2 Technical and Constructional Requirements

The following requirements shall apply:

3.4.7.2.1 Common for all Instrument Transformers

Bushing Insulators

a) The instrument transformers shall be oil filled with porcelain/silicone rubber housing bushings suitable for outdoor service and upright mounting on steel structures.

b) Bushing/Insulators shall conform to requirements of Clause 3.4.11.

c) Bushings shall be provided with oil filling and drain plugs, oil sight glass for CT and for electromagnetic unit of CVT etc.

d) Instrument transformers shall be hermetically sealed units. The Bidder/Bidder shall furnish details of the arrangements made for the sealing of instrument transformers.

e) Polarity shall be marked on each instrument transformer and at the lead terminals at the associated terminal block.

Box

Each single phase instrument transformers shall be complete with its terminal box. The terminal box shall meet the requirements of IP 55 relevant IEC Standard. A marshalling box for a set of 3 instrument transformers shall be provided, wherever required.

Tank

The Instrument transformer tank along with top metallics shall be hot dip galvanised or painted.

Lifting Arrangements

Instrument transformer shall be provided with suitable lifting arrangement, to lift the entire unit. The lifting arrangement shall be clearly shown in the general arrangement drawing.

3.4.7.2.2 Current Transformers (CT)

a) Current transformers shall have single primary either ring type, or bar type (live tank), or hair pin type (dead tank) and suitably designed for bringing out the secondary terminals in a weather proof terminal box at the bottom. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box.

b) Different ratios, as specified/required shall be achieved by secondary taps only and primary reconnection shall not be acceptable.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys.

d) The expansion chamber at the top of the insulators shall be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks for star/delta formation, short circuiting and grounding of CT secondary terminals.

f) The guaranteed burdens and accuracy class are to be simultaneous for all cores. The accuracy class for measuring cores shall be met upto the rated extended primary current.

g) For 420 kV class CT's the rated extended primary current of the CT's shall be 200% of rated primary on all except (one) highest tap ratio. On the highest tap ratio, the rated extended primary current shall be 120% for line bays.

h) The current transformer shall be suitable for horizontal transportation.

i) The instrument security factor of metering core at all ratios shall be less than 5. If any auxiliary CTs/reactor are used in the current transformers than all parameters specified/required shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CT. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably

wired up to the terminal blocks.

j) The current transformers shall be suitable for high speed auto-re-closing, if required.

k) Special Technical Requirements

Through Fault Capability The current transformers shall be capable of withstanding with the secondary short circuited, a fully offset primary current having an ac (i.e. symmetrical) component with an rms value equal to the specified short-circuit capacity of the system. The CT's shall withstand the discharges of filter banks after ground fault.

Transient Performance (If applicable) The current transformers shall meet the requirements for transient performance and tests shall be conducted accordingly.

3.4.7.2.3 Voltage Transformers

a) Voltage transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling.

b) The electromagnetic unit consisting of compensating reactor, intermediate transformer, protective and damping devices etc. shall also be mounted in a hermetically sealed metal enclosure, which shall also be used as a mechanical support for the capacitor voltage divider. The terminals of the secondary windings of the electromagnetic units shall be brought out in a separate, weather proof terminal box, which shall be properly mounted on the wall of the metal enclosure of the electromagnetic unit. Suitable quantity of silica gel shall also be provided in a suitable porous container.

c) The capacitor voltage divider shall be capable of being used over a wide carrier frequency band-width. The value of capacitance shall be suitably chosen for reliable wide band carrier coupling and shall not be less than the value specified in the Appendix A1 of Schedule A of Volume 3 of 3. The reactance of the teed branch of the CVT shall be adjusted to minimize carrier loss. With carrier frequency coupling device connected to the earth lead of the intermediate coupling capacitor, the accuracy of the electromagnetic voltage transformer unit shall remain within the specified limits.

d) Each core of secondary winding to be used for protection purpose shall be protected by MCB's of suitable rating. NO and NC contacts shall be provided on the MCB for monitoring purposes. The secondary terminals of the CVT's shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the MCB's.

e) The accuracy of metering winding shall be maintained through out the entire burden range upto total burden simultaneously on all the three windings

without any adjustments during operation.

f) It shall be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

g) A protective surge arrester shall be provided to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor/RF choke etc. due to short circuit in transformer secondaries.

h) Special Technical Requirements

i) Transient Response

The transient response (at rated frequency and beyond) shall be such that, after sudden removal of the primary voltage, the transient secondary voltage in the capacitor voltage transformer shall not exceed 10 (Ten) percent of the peak value of the secondary voltage existing before the collapse of the primary voltage to zero nor it shall exceed value required to meet the performance. This value shall be measured (oscillograms) following the primary short circuit when the capacitor voltage transformer is loaded with 25% and 100% of rated burden at 0.8 power factor lagging.

ii) Ferro-resonance

The Ferro-resonance requirement shall be met as per the relevant standards.

iii) Protective Device

A protective device shall be incorporated in the capacitor voltage transformer for the purpose of limiting over voltages which may appear across one or more of its components. The device shall include a heavy duty class spark gap with adjustable setting and drain coil. The setting of the protective device shall be determined by the Bidder, however, it shall be adjustable and shall not introduce distortion in the secondary voltage wave shape at rated frequency and at an applied voltage up to 1.2 per unit of nominal voltage. Should the protective device operate on switch surge or atmospheric over voltages, the secondary voltage shall recover to its correct wave shape within 4 ms when the applied voltage is 1.2 per unit of nominal voltage.

iv) Power Line Carrier

Coupling Application If required, the capacitor voltage transformers shall be equipped with power line carrier coupling components, and the capacitance value shall be that required for PLCC coupling purposes.

v) Reproduction of Harmonics

Harmonics with frequency 100 Hz to 650 Hz superimposed on the fundamental frequency shall be reproduced within an accuracy of amplitude error of 10% & phase angle error (for each separate harmonic) of 10 degree elect.

vi) Reproduction of Transients

A step of 10% of rated voltage (rms) superimposed on the primary voltage shall be reproduced at maximum burden with a delay (time constant) of less than 100 microsecond and within +10% of correct value within 400 microsecond.

3.4.7.3 Type Tests

The current transformers shall be type tested as per the requirements of IEC: 60044-1 and the voltage transformers shall be type tested as per IEC-60044-5.

3.4.7.4 Routine Tests

The current transformers shall be subject to routine tests as per IEC: 60044-1 and the voltage transformers shall be routine tested as per IEC- 60044-5. Additional routine tests as specified below shall also be conducted on each unit:

Current Transformers

a) Measurement of capacitance

b) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 $Um/\sqrt{3}$

c) Oil leakage test

Voltage Transformers

a) Capacitance and loss angle measurement before and after dielectric tests as per IEC

b) Sealing test as per IEC

3.4.7.5 Technical Parameters

The technical parameters shall be determined by the Bidder. Refer to Appendix-A1 of Schedule-A of volume 3 of 3 (Schedule of Requirements) for the technical parameters for Instrument Transformers generally used by the Employer and are furnished for the information of the Bidder.

3.4.8 Surge Arresters

3.4.8.1 General

Surge arresters shall be of the type employing non-linear metal oxide resistors without spark gaps. The Bidder shall demonstrate by calculations that the surge arresters will adequately protect the switchgear arrangement proposed.

3.4.8.2 Operating Duty and Performance

The protective characteristics and discharge duties shall be determined by the Bidder. The arresters shall give consistent protection to their associated equipment against over voltages produced by lightning, switching, station internal or external faults, and other system disturbances.

The arresters shall be rated and tested such that they are able to discharge a specified maximum energy due to the application of temporary voltages of form and magnitude which can occur in service as determined by insulation coordination studies to be carried out by the Bidder, without coming into the temperature region where thermal runaway could result upon subsequent application of maximum transient and steady state voltage conditions.

Particular attention shall be given to the high discharge currents which some of the arresters may experience in service due to the requirements to discharge the energy of the, shunt capacitors and reactive compensating equipment or in other circumstances.

The design of the arresters shall take into account and shall maximize the degree of current sharing between complete arresters. Similarly the design shall also take into account and shall maximize the degree of current sharing between parallel columns of the same arrester.

420 kV class AC arrester shall be capable of discharging energy equivalent to at least class 3 of IEC on two successive operations followed immediately by 50 Hz energization with a sequential voltage profile at least as specified below:

- 705 kVp for 3 peaks
- 580 kVp for 0.1 sec
- 565 kVp for 1sec
- 550 kVp for 10 sec.

The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage. The Bidder/Bidder shall furnish the values and supporting calculations along with the Bid. The arresters shall be fully stable thermally under site conditions and shall take care of the effect of direct solar radiation.

3.4.8.3 Constructional Features

Surge arresters shall be housed in polymer insulators designed to withstand

extremes of the environment described. The insulation shall have a minimum creepage distance of 25 mm/kV rated system phase to phase voltage. The method of sealing against the ingress of moisture shall be of a type well proven in service and the manufacturing procedures shall include an effective leak test which can be demonstrated to the inspecting engineer if required.

The internal components of arresters shall be arranged to minimise radial voltage stresses, internal corona and to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the polymer housing. Except where approved, organic materials are not permitted.

Good electrical contact shall be maintained between resistor blocks taking account of any thermal expansion and contraction of the block or mechanical shock during transport and erection, by installing a well proven clamping system.

Metal oxide arresters installed outdoors shall be able to dissipate, when new, twice the energy generated in the resistor blocks when energized at their maximum continuous operating voltage immediately having been subjected to the discharge duties specified in IEC 60099-4 and assuming that the polymer housing and the surrounding air is at least 5˚C higher than the maximum ambient air temperature specified.

Good quality control of the manufacturing process of the resistors shall be ensured by rigorous testing procedures. The procedures shall ensure that the characteristics of the blocks are, and will remain, within the specified limits when new and throughout the anticipated life of the arresters. Samples may be selected at random by the Engineer for special tests to be agreed with the manufacturer.
All surge arresters shall be fitted with a pressure relief diaphragm which shall prevent explosive shattering of the polymer housing in the event of an arrester failure and the arrester shall have been tested according to the high and low current tests specified in IEC 60099-1.

3.4.8.4 Fittings and Accessories

Arresters shall be supplied complete for installation in an outdoor switchyard, including insulating bases and surge counters, one per phase, and, if applicable, grading rings. The material used for terminals shall be compatible with that of the conductors to which they are to be connected.

Each arrester shall be identified by a rating plate in accordance with the requirements of IEC 60099-4. In addition an identification mark shall be permanently inscribed on each separately housed unit of a multi-unit arrester so that units can be replaced in the correct position in the event of them being dismantled.

Surge counters shall have an internal assembly which is matched to the line

discharge capability of the arrester and shall include a leakage current meter with a bi-linear scale for ease of reading. Auxiliary contacts are to be provided to signal remote indication of counter operation.

3.4.8.5 Tests

Arresters shall be designed and tested in accordance with the requirements of IEC 60099-4. Any departure shall be the subject of agreement between the Engineer and the Bidder. Routine tests shall be carried out in accordance with the requirements of Section 15 of this Specification.

3.4.8.6 Technical Parameters

The technical parameters shall be determined by the Bidder. Refer to Appendix-A1 of Schedule-A of volume 3 of 3 (Schedule of Requirements) for the technical parameters for surge arrestor generally used by the Employer and are furnished for the information of the Bidder.

3.4.9 Neutral Grounding Resistors

The earthing resistors shall be of the metal grid type with enclosure having degree of protection IP 33 and suitable for outdoor service on the neutral earthing system as specified. The framework and enclosure shall be of galvanised steel. The grids shall be adequately supported on steel rods and porcelain insulators and be designed to withstand the currents flowing under fault conditions. Adequate insulating barriers shall be provided to prevent internal flashover.

The resistor shall be complete with lifting and jacking lugs, access panels, holding down bolts or clamps, earth terminals, connectors and connections. The bushing shall have a minimum creepage distance of 25mm/kV of rated system phase to neutral voltage.

The specified resistance shall be that at the design ambient temperature and it shall be capable of passing the specified current for 10 seconds with a maximum temperature rise as stated in the Schedule of Guarantees.

3.4.10 Busbars, Conductors and Connections

Busbars and electrical connections in outdoor substations shall be in accordance with BS 215, 159 and 2898 and relevant IEC standards in respect of current rating and material analysis.

Overhead conductors carried by the switchyard structures shall be erected with such sags and tensions that when the conductors are subjected to the load combinations in Section 11, the factor of safety will not be less than 3.5. The switchyard structures shall be designed considering the sag limit at minimum ambient temperature (50c) in still air not exceeding one(1) percent

of the horizontal span length. Conductor sag chart and clearance data shall be subject to approval of Engineer.

Materials used for busbars and connections shall be stressed to not more than two-fifths of their elastic limit. Provision shall be made for expansion and contraction with variation in conductor temperature and busbars shall be arranged so they may be readily extended in length with a minimum of disturbance to existing equipment.

Tubular bus conductor shall be used for 400kV, 230KV and 132kV busbar and supported by station post insulator.

3.4.10.1 Tubular Bus Conductors

General

Aluminium used shall be of grade 63401 WP conforming to relevant IEC/BS Standard.

Constructional Features

a) For outside diameter (OD) & thickness of the tube there shall be no minus tolerance. The other requirements shall be as per IEC 114.

b) Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be small drain hole at the end of each corona bell.

c) The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be furnished for approval of the Employer. Material for welding sleeve shall be same as the Aluminium tube.

Parameters

The size and other parameters of tubular bus conductors suitable for the busbar specification stated in Appendix A1 in Volume 3 of 3 of the bid document shall be determined by the Bidder.

Tests

The tests shall be conducted on tubular bus conductors as per relevant IEC Standard. Also the wall thickness and ovality of the tube shall be measured by ultrasonic method. In addition to the above tests, 0.2% proof test on both parent metal and aluminium to be after welding shall be conducted.

3.4.10.2 Flexible Bus-Bars and Earthwire

General

The conductors shall conform to relevant IEC/BS Standard. The number and diameters of the individual wires forming the finished conductor shall be subject to approval of Engineer.

Constructional Features

Workmanship

All the aluminium strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding. The finished conductor shall have a smooth surface without any surface cuts, abrasions, scuff marks and shall be free from dirt, grit etc.

Joints in Wires

No joints shall be permitted in the individual wires in the outermost layer of the finished conductor. However, joints in the inner layers of the conductor shall be allowed but these joints shall be made by cold pressure butt-welding and shall be such that no two such joints are within 15 metres of each other in the complete stranded conductor.

Materials

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeds 0.04%.

Parameters

The size, rating, number of conductors per phase and the configuration, etc. shall be determined by the Bidder.

Tests

The following type, acceptance and routine tests and tests during manufacture shall be carried out on the conductor in addition to the tests specified in relevant applicable standards.

Type Test

DC Resistance Test on Stranded Conductor On a conductor sample of minimum 5 m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by Kelvin double bridge by placing the clamps initially zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20 0C as per relevant IEC Standard.

Acceptance Test

i) Visual and Dimensions check on Drums

ii) Visual Check for Joints, Scratches etc.

iii) Dimensional check on Aluminium Strands

iv) Check for lay-ratios of various Layers The following tests shall be conducted once on sample/samples of conductor.

- Breaking load test on aluminium strands

- Wrap load test on aluminium strands

- DC resistance tests on aluminium strands

All the above tests shall be carried out on aluminium strands after stranding only.

Routine Tests

i) Check to ensure that the joints are as per specification.

ii) Check that there are no cuts, fins, etc. on the strands.

iii) Check that drums are as per specification.

iv) All acceptance tests as mentioned above are to be carried out on each coil

Tests During Manufacture

Chemical Analysis of Aluminium used for making aluminium strands Samples taken from the aluminium ingots/coils/ strands shall be chemically/spectrographically analyzed. The same shall be in conformity to the specified requirements.

Packing

The conductor shall be supplied in strong wooden drums constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The drums shall generally conform relevant IEC/Standard. Only one length of conductor shall be wound on each drum.

3.4.10.3 Clamps & Connectors

General

a) Conductor clamps shall be compression type except for shield wire in accordance with BS 3288 and shall be made of materials listed below :

For connecting ACSR conductors: Aluminium alloy casting
For connecting equipment terminals made of copper with ACSR conductors: Bimetallic connectors made from aluminium alloy casting with 2mm thick

Bimetallic liner
For connecting G.I. Shield wire : Galvanised mild steel
Bolts, nuts & Plain washers: Electro galvanised for sizes below M12, for others hot dip galvanised
Spring washers: Electro-galvanised mild steel suitable

b) Equipment shall be supplied with the necessary terminals and connectors, as required by the ultimate design for the particular installation. The conductor terminations of equipment shall be either expansion, sliding or rigid type. The requirements regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. In case the connector is not available then equivalent connector may be used. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included under this scope of Work.

c) Where copper to aluminium connections are required, bi-metallic clamps shall be used, which have been properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress. The design details of joint shall be furnished to the Employer.

d) Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified are also included in the scope of Work.

e) No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2mm thickness shall be cast integral with aluminium body for Bi-metallic clamps. When copper alloy is not cast integral with aluminium body, a bimetallic washer or strip shall be used to meet the functional requirement.

f) All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

g) Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of IPS Aluminium tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

h) Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

i) All current carrying parts shall be designed and manufactured to have

minimum contact resistance.

Constructional Feature

All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off. Size of the terminal/connector for which the clamp/ connector is suitable shall be embossed/punched (i.e. indelibly marked) on each components of the clamp/connector, except on the hardware. The clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/ connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware. All current carrying parts shall be designed and manufactured to have minimum contact resistance. The Corona extinction voltage for 400 kV, 230KV and 132 kV class clamps shall not be less than 320 kV and 156 kV respectively.

Tests

The clamps and connectors shall be subject to type and routine tests as per relevant IEC Standard. Type tests as per IEC Standard shall be carried out on one sample of each type and design. One sample of each type and design shall also be type tested for:

a) Temperature rise test

b) Short time current test

c) Dry corona and RIV test

d) Resistance test and tensile test

3.4.10.4 Spacers

General

The spacers shall conform to relevant IEC/ BS Standard.

Constructional Features

No magnetic material should be used in the fabrication of the spacers except for the GI bolts and nuts. Spacer design shall be made to take care of fixing and removing during installation and maintenance. The design of spacer shall be such that the conductor does not come in contact with any sharp edge.

Tests

The spacers shall be subjected to the type tests, acceptance tests and routine tests in accordance with relevant IEC/BS Standard.

3.4.11 Insulators, Bushings, Buses and Hardware

3.4.11.1 Bushings and Support Insulators

General

Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-60233. The support insulators shall be manufactured and tested as per IEC-60168, IEC-60273. The insulators shall also conform to IEC-60815 as applicable. All bushings shall be one piece only and no joints shall be accepted.

Constructional Features

a) Porcelain used shall be homogeneous and free from imperfections that might affect the mechanical or dielectric quality.

b) Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. The ground surface shall not be glazed.

c) Condenser type bushing shall be provided with :

   i) Oil level gauge.

   ii) Oil filling plug and drain valve if not hermetically sealed.

   iii) Tap for capacitance and tan delta test.

d) When bushings have an under-oil end of re-entrant form, the pull through lead shall be fitted with a gas bubble deflector.

e) Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

f) Bushings of identical rating shall be interchangeable.

g) No arching horns shall be provided on the bushings.

h) All ferrous parts shall be hot dip galvanized or zinc plated and passivated. All joints shall be air tight. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

i) Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they shall be used.

j) When operating at rated voltage there shall be no electric discharge between conductor and insulators which would cause damage to conductors or insulators by the formation of substances produced by chemical action. No

radio interference shall be caused when operating at rated voltage.

k) The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

l) The Bidder/Bidder shall define the type of insulator (type A or B) as per IEC-60168.

m) Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

n) Special precaution shall be taken to exclude moisture from paper insulation during manufacture, assembly, transport and erection. The surface of all paper insulation shall be finished with non-hygroscopic varnish which can not be damaged easily.

o) Each porcelain insulator shall have marked upon it the manufacturer's name or identification mark and year of manufacture. These marks shall be clearly legible after assembly of fittings and shall be imprinted before firing, not impressed. Each complete bushing shall be marked with the manufacturer's name or identification mark, year of manufacture, serial number, electrical and mechanical characteristics in accordance with IEC 60137:1973.

Parameters

The parameters shall be determined by the Bidder, however the minimum performance parameters for the 420 kV and 132 kV class post insulator shall be as per the stipulation of Schedule-A of Volume 3 of 3(Schedule of Requirements).

Tests

Each type of bushing and insulator shall be subjected to type and routine tests in accordance with applicable standards and acceptance test shall include one minute dry power frequency withstand test and ultrasonic test (except for hollow insulator). The ultra sonic test shall be done on the porcelain before assembly. All sample tests and special tests shall also be conducted.

3.4.11.2 String Insulators & Hardware

General

The insulators for suspension and tension strings shall conform to relevant IEC/Standard. Insulator hardware shall conform to relevant IEC/Standard. The insulation levels shall be determined by the Bidder but the minimum performance characteristics shall be as specified in Schedule A of Volume 3 of 3.

Constructional Features

a) Requirements specified in Clause 3.4.11.1 above shall also be applicable equally to string (disc) insulators.

b) Suspension and tension insulators shall be wet process porcelain with ball and socket connections. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on porcelain printed and applied before firing.

c) Insulator hardware shall be uniform to the requirements stipulated for clamps and connectors under Clause 3.4.10.3.

d) Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating condition.

e) Insulator hardware assembly shall be designed as per the design requirement but for at least 4000 Kg. tensile load per phase for the switchyard with a factor of safety two (2). Similarly ground wire tension clamp shall be designed for at least 3500 kg tensile load with a factor of safety of two (2).

f) Tension string assembly shall be supplied along with suitable turn buckle (one turn buckle per string).

g) All hardware shall be bolted type.

h) As an alternative to disc insulator string, the Bidder/Bidder can provide a combination of long rod insulators, with suitable hardware. This combination shall be suitable for application specified and should offer the same equivalent parameters as would be available from the insulator string composed of specified disc insulators and hardware combination. Further the complete long rod insulator string shall be subject to the specified tests and the insulator shall also be subject to all tests as per relevant standards. All other constructional features specified above shall also apply to the long rod insulator string.

Parameters

The minimum parameters of insulator discs/complete insulator strings shall be as per the stipulation of Schedule-A of Volume 3 of 3(Schedule of Requirements).

Tests

The insulators for suspension and tension strings and hardware shall be subjected to the following type tests, acceptance tests and routine tests.

a) Type Tests on Insulator Strings:

   i) Dry and Wet Power Frequency Voltage withstand test with corona control rings and arcing horns

   ii) Dry and Wet Switching surge voltage withstand test with corona control Ring

   iii) Dry and Wet Impulse Voltage Withstand test with corona control rings

   iv) Voltage distribution test

   v) Corona and RIV test (Dry Condition)

   vi) Mechanical strength test

b) Type Tests on Disc Insulators:

   i) Thermal and Mechanical performance tests

   ii) Power frequency puncture withstand voltage

   iii) Steep front wave test to be conducted as follows:

   - This test shall be performed on five samples taken at random
   - The insulators shall be subjected to five(5) positive and five (5) negative impulses with wave fronts of at least 2500 kV/microsecond
   - In the case of low flashover values of porcelain puncture, the number of samples shall be doubled or another test shall be performed.

   iv) Results of the second test should not show porcelain puncture

c) Acceptance Tests for Disc Insulators:

   i) Visual examination

   ii) Verification of Dimensions

   iii) Temperature Cycle Test

   iv) Puncture Test

   v) Galvanizing Test

   vi) Mechanical performance Test

vii) Test on locking device for ball and socket coupling

viii) Porosity test

ix) Electromechanical test

d) Type Test on Hardware Fittings Only:

i) Magnetic power loss test for suspension assembly (For both suspension and drop clamps)

e) Acceptance Test on Hardware Fitting:

i) Visual Examination

ii) Verification of Dimensions

iii) Galvanizing/Electroplating tests

iv) Slip strength test

v) Shore hardness test for Elastometer (if applicable)

vi) Mechanical strength test for each component (including corona control rings and arcing horns)

vii) Mechanical strength test on corona control rings

viii) Test on locking devices for ball and socket coupling

f) Routine Test on Disc Insulator/Long Rod Insulator:

i) Visual Inspection

ii) Mechanical Routine Test

iii) Electrical Routine Test

g) Routine Test of Hardware Fittings:

i) Visual examination

ii) Mechanical strength test

h) Test During Manufacture on all Components as Applicable on Disc Insulator:

i) Chemical analysis of zinc used for galvanizing

ii) Chemical analysis, mechanical hardness tests and magnetic particle inspection for malleable casting

i) Test During Manufacture on all Components as Applicable on Hardware Fittings:

i) Chemical analysis of zinc used for galvanizing

ii) Chemical analysis, mechanical hardness tests and magnetic particle inspection for forgings.

iii) Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricated hardware.

Test Procedures

a) Voltage Distribution Test(Dry)

The string shall be energised with 100 kV power frequency voltages. The voltage across each insulator unit shall be measured by using a high impedance voltmeter. The voltmeter shall be calibrated before and after the measurement. The voltage across any disc shall not exceed 9% of the applied voltage for single and double suspension insulator string and 10% for double tension insulator strings.

b) Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 320 kV line to ground under dry conditions. There shall be no evidence of corona on any part of the sample when all possible sources of corona are photographed in a darkened room.

c) RIV Test (Dry)

Under the conditions as specified under b) above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 266 kV (rms) line to ground under dry conditions. The test procedure shall be in accordance with IEC-60437-1973.

d) Mechanical Strength Test

The complete insulator string along with its hardware fittings shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

e) Magnetic Power Loss Test for suspension assembly (for both drop and suspension clamp)

Two hollow aluminium tubes of 32 mm dia. shall be placed 450 mm or 250 mm apart depending upon the voltage level at which test is to be done. An alternating current in the range of 200 to 600 Amps. shall be passed through each tube. The reading of the wattmeter with and without two suspension assemblies along with the line side yoke plate clevis eye shall be recorded.

Not less than three suspension assemblies shall be tested. The average power loss for the suspension assembly shall be plotted for each value of current. The value of loss corresponding to 300 Amps shall be read from the graph. The magnetic power loss of the clamp assembly with entire line fitting shall not exceed 4 watts at 600 Amps current (rms).

f) Mechanical Strength Test of each component

The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in f) above should be followed.

g) Chemical Analysis of Zinc used for galvanizing

Samples taken for the zinc ingot shall be chemically analyzed as per relevant IEC Standard. The purity of zinc shall be not less than 99.5%.

h) Test for Forgings, Castings & Fabricated Hardware

The chemicals analysis, mechanical hardness tests and magnetic particle inspection, shall be as per the internationally recognized procedures for these tests. The sampling shall be based on heat number and heat treatment batch. The details regarding test shall be mutually agreed to by the Bidder and the Employer.

3.4.12 Interlocking Facilities

Disconnectors, earthing switches, circuit breakers, etc., shall be provided with an interlocking system which ensures safe operation of the equipment under all service conditions.

The interlocking scheme shall be designed for the final substation arrangement. The items of plant supplied under this Contract shall be complete with all interlocking facilities needed for the final arrangement, avoiding the need for future modifications.

Where mechanical key interlocks are employed, they shall be effective at the point where hand-power is applied so that stresses cannot be transferred to parts remote from that point.

Tripping of the circuit-breaker shall not occur if any attempt is made to remove a trapped key from the mechanism. Emergency tripping devices shall be kept separate and distinct from any key interlocking system and shall be clearly labelled, suitably protected from inadvertent operation but readily accessible.

Circuit-breakers shall be interlocked so that, except under maintenance conditions, it is not possible to close a circuit-breaker unless the selected busbar and circuit disconnectors are closed.

Except as stated below, disconnectors shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open. Where

power transformers are banked together, the individual transformer disconnectors shall be interlocked so that it is not possible to make or break load current at the disconnectors.
Provision for on load transfer of feeder circuits from one busbar to another shall be made possible by interlocks which ensure that the section disconnectors, bus coupler and its disconnectors are closed.

All electrical interlocks shall so function as to interrupt the operating supply, and an approved system of interlocks shall be provided which shall cover the emergency hand operation of apparatus which is normally power operated. Failure of supply (or its restoration after an outage) or of connections to any electrical interlock shall not produce or permit faulty operation. Electrical bolt interlocks shall be energised only when the operating mechanism is being operated. Visible indication shall be provided to show whether the mechanism is locked or free. Approved means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

3.4.13 Auxiliary Switches and Contactors

Circuit-breakers, disconnectors and earthing devices and circuit selector disconnectors shall be provided with suitably rated auxiliary switches and contactors, where permitted, to relay circuit information for the purpose of control, protection, indication and metering at the substation site as required by the relevant section of the Specification. In addition they shall be provided with auxiliary contacts for position indication to the central system control room via the remote supervisory system. Disconnector auxiliary switches are not to be used for current transformer switching circuits.

Auxiliary contactors shall be provided only where the circuit requirement cannot be met by the auxiliary switch arrangements and multiple contactors and relays will not be accepted in lieu of the auxiliary switches except as specifically approved by the Engineer. Auxiliary switches and contactors shall comply with the requirements of this Specification and in particular shall be capable of operation within the same voltage limits as specified for the associated circuit-breaker close and trip coils.

The connections of all auxiliary switches, including spares, and contactors as well as the associated coil connections and interconnections between auxiliary switches, shall be wired to a terminal board located in the operating cubicle or other approved position.

Auxiliary switches and contactors shall be mounted in an approved accessible position clear of the main operating mechanism but with a minimum of additional mechanical linkages and housed in a substantial weatherproof enclosure. Where adjustable linkages are provided to facilitate the timing of the auxiliary switches with respect to the main equipment, approved locking devices shall be fitted.

Auxiliary switch contacts shall be positively operated, make with a wiping action and, where necessary, discharge resistors shall be provided to prevent arcing when breaking inductive circuits.

Except for the contacts employed for control and interlocking, the requirements for auxiliary switches in respect of timing shall be as follows:-

For Circuit-Breakers

Normally open contacts, with the exception of two sets of this type, shall close in about 10 milliseconds after the making of the main circuit-breaker contacts and shall open in about 10 milliseconds before the separation of the main circuit-breaker contacts whilst the two remaining sets shall close in about 5 milliseconds before the making of the main circuit breaker contacts and open simultaneously with the main circuit contacts.

Normally closed contacts shall close 10 milliseconds after the opening of the main circuit-breaker contacts and open at least 10 milliseconds before the making of the main circuit-breaker contacts.

For Busbar Disconnectors

The operating sequence of any disconnector auxiliary switches used in D.C. circuits for high impedance busbar zone protection shall be such that the auxiliary switches operate:-

a) before reaching the pre-arcing distance on closing the disconnector.

b) after the pre-arcing distance has been exceeded on the opening of the disconnector.

Auxiliary switches shall be adjustable from normally-open to normally-closed or vice-versa.

For Line Disconnectors

As for Busbar disconnector auxiliary switches.

For Earthing Switches

As for Busbar disconnector auxiliary switches.
Any deviation from the above should be stated in the Schedule F of Deviations from Specification.

3.5 Interference with Existing Equipment

Work carried out on site in extending equipment or modifying the existing substation shall be so arranged as to cause minimum interference with existing plant and equipment and interruption to supplies. The Bidder shall include in his price for the provision, erection, commissioning and subsequent dismantling and removal from site of any temporary structures, insulators and connections that may be necessary to maintain continuity of supply whilst certain sections of the plant are out of service to permit the

execution of the Works.

If it is necessary to reposition any of the existing substation plant in order to incorporate the specified works or to comply with specific requirements, all costs incurred in dismantling, removing, modifying, repositioning, existing and commissioning of such equipment shall be deemed to have been included in the Bid Price.

The repositioning of any plant is subject to the specific approval of the Employer. Existing plant rendered redundant by this Contract shall remain the property of the Employer and shall be returned to the Employer's store.

Permission for access to existing substations to execute the Works shall be obtained in writing from the Employer. The Bidder shall conform to the Employer's Safety Rules in all respects when working in or near existing plant.

Extensions at the existing substation shall be carried out maintaining the same busbar centres, heights etc., other essential dimensions and interlocking schemes.
Where stated in the Schedule of Requirements, equipment for existing substations shall be of the same type and manufacture as that already in service.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 4

POWER TRANSFORMERS

SECTION 4

POWER TRANSFORMERS

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SECTION 4

POWER TRANSFORMERS

4.1 SCOPE

These clauses describe the General Technical Requirements for Power Transformers; autotransformer to be installed shall be read in conjunction with the Requirements in Volume 3 of 3.

"Installation, testing & commissioning of power transformer shall be done by the transformer engineer(s) of the power transformer manufacturer(s)."

4.2 REFERENCES

4.2.1 IEC Standards

IEC 60044 Instrument transformers-Part 1: Current transformers
IEC 60044 Instrument transformers-Part 2: Inductive volatage Transformers
IEC 60060 High voltage testing techniques (Part 1 & 2)
IEC 60099 Surge arrestor (Part 4 & 5)
IEC 60076 Power transformers (Parts 1, 2, 3, 4, 5, 6, 7, 8 & 10)
IEC 60137 Insulated bushings for alternating voltages above 1000V
IEC 60214 On load tap changers (Parts 1 & 2)
IEC 60228 Conductors of insulated cables
IEC 60270 Recommendation for partial Discharge measurements
IEC 60296 Specification for unused mineral insulating oils for transformers and switchgear
IEC 60422 Supervision and maintenance guide for mineral insulating oils in electrical equipment
IEC 60439 Low voltage switchgear and controlgear assemblies (Parts 1 & 2)
IEC 60529 Degrees of protection provided by enclosures
IEC 60815 Guide to the selection of insulators in respect of polluted condition

4.2.2 British Standards

BS 61 Specification for threads for light gauge copper tubes and fittings
BS 381C-1996 Color Standards for General Purpose
BS 729 Hot Dip Galvanizing
BS 2569 Cleaning Before Painting
BS 3600 Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure

purposes
BS 4504 Circular flanges for pipes, valves and fittings (PN designated)
BS 5493 Painting
BS 6121 Mechanical cable glands
BS 6346 Specification for PVC insulated cables for electricity supply
BS 6435 Specification for unfilled enclosures for the dry termination of HV cables for transformers and reactors
BS 7354 Code of practice for design of HV open terminal stations

4.2.3 BS European Standards

BS EN 10029 Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick and above

4.3 POWER TRANSFORMERS

4.3.1 Types of Transformer and Operating Conditions

i) General

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076, Parts 1 to 8 & 10 inclusive.

Electrical clearances shall not be less than as stated in the Project Requirements in Volume 3, whichever is the greater.

ii) Cooling

The types of cooling shall be as stated in the Schedule A of Requirements and the letters relating to the method of cooling used in this Specification and Schedules shall be in accordance with IEC 60076.

Where a combination of two methods of cooling is applied to one transformer, as for ONAN/ONAF units, the transformer shall be capable of operating under the ONAN condition as stated in the Schedule of Requirements, after which the cooling equipment is to come into operation and the Transformer will operate as an ONAF unit. Failure of one fan shall not reduce the continuous maximum rating of the transformer.

The capacities of each cooling stage as per voltage level are defined as follows:

		ONAN	ONAF
230/132/33kV	HV, LV	225 MVA	300 MVA
	TV	75 MVA	100 MVA
132/33kV	HV, LV	80 MVA	120 MVA

iii) Parallel Operation

Transformers supplied against each item shall be designed to operate satisfactory, one with the other, when operating on the same tap position.

iv) Handling on Site

For installation purposes and to permit the moving of transformer, the transformers are to be equipped with castors (rail wheels). A permanent rail transfer track system shall be provided, integrated with the transformer foundations. The castors should be able to swivel in both the longitudinal and transverse directions.

A system of wedges shall be included to stop any unwanted movement of the transformer during its operating life. The distance between rails must be compatible with the transformer dimensions and also the rail gauge prevailing at existing substation sites.

4.3.2 Continuous Maximum Rating

Transformers shall have the rating stated in the Schedule of Requirements and shall comply with the requirements as regards temperature rise and overloads on all tappings, irrespective of the direction of power flow and with the voltage of the lower voltage winding at the normal voltage stated in the Schedule of Requirements. To allow for high atmospheric temperatures, the allowable temperature rises shall be reduced in accordance with IEC 60076-2.

The overload capability shall be in accordance with IEC 60076-7.

4.3.3 Electrical Connections

Transformer windings shall be connected in accordance with the Vector group symbol specified in the Schedule of Requirements and as per IEC 60076.The neutral point of star connected winding shall be brought out for grounding.

All electrical connections within windings shall be brazed but, subject to approval, mechanically crimped joints may be used for round stranded conductors on tapping, bushing or earthing connections and on bundle conductors where design has been proved by type test and application is subject to rigorous quality control.

4.3.4 Ability to Withstand Short Circuit

i) General

All transformers shall be capable of withstanding, on any tappings and without damage, the thermal and dynamic effects of external short circuits under the conditions stated in IEC 60076 Part 5. For this purpose the design short circuit level for each system voltage is stated in the Schedule of Requirements of volume 3 of 3.

ii) Calculations and Tests

Evidence shall be submitted with the Tender as to the extent to which the manufacturer has proved, or is able to prove, either by calculation or test, the ability of the specified Transformers to withstand short circuit.

The Bidder shall provide with his Tender a brief description of those transformers, or parts thereof, which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers tendered but, in the event this is not so, the Engineer reserves the right to require calculations to prove that the design of transformers tendered will satisfactorily comply with this Clause.

4.3.5 Stabilizing Windings

Unless otherwise specified in the Schedule of Requirements, the product of the number of turns of the stabilizing windings and the cross- sectional area of one such turn must not be less than 33 per- cent of the corresponding product for the untapped main winding.

When required by the Schedule of Requirements, the stabilizing winding shall be capable of carrying continuously the load specified therein.

4.3.6 Losses and Evaluation of Losses

Guaranteed values for component losses of the total loss which shall be as low as is consistent with transport restrictions, reliability and economic use of materials, shall be as stated in the Schedule E of Particulars and Guarantees.

Tenders will be assessed on the basis of the least 'Present Worth' of capital cost plus guaranteed losses, being the sum of the installed Tender Price of the transformers plus a sum which shall be:-

For each unit of the three-phase/single-phase transformers,

To arrive at an "evaluated bid price", operating costs of the transformers (each transformer of the scope, except the auxiliary transformer) will be taken into account which includes the capitalization of transformer losses which will be evaluated in accordance with the following formula.

For each unit of transformer, Capitalization of transformer losses
=N x a + L x b + M x c

Where,

N = Average No-load loss (core loss) at 75^0C in kW

L = Average Load loss (copper loss) at 75^0C in kW

M = Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all cooling fans are in operation)

a = Cost/kW of average no-load loss (core loss) valued at 600,000 Bangladesh Taka

b = Cost/kW of average load loss (copper loss) valued at 300,000 Bangladesh Taka

c = Cost/kW of auxiliary power valued at 300,000 Bangladesh Taka

The acceptance of transformers yielding component losses higher than the guaranteed values shall be governed by either of the following:-

(a) Component losses in excess of guaranteed values but within the tolerance permitted under IEC 60076 Part 1.

Transformers shall be acceptable subject to full compliance with all technical particulars, including temperature rises at CMR and subject to the Bidder accepting deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above evaluation rates.

(b) Component losses in excess of guaranteed values and exceeding the tolerance permitted under IEC 60076 Part 1.

The acceptance of transformers shall be entirely at the discretion of the Employer and subject to the Bidder accepting the deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above loss evaluation rates.

In the event of transformers yielding component and total losses which are either equal to or below the guaranteed values, the Bidder will not be entitled to any premium in respect of reduction in losses below the guaranteed values.

4.3.7 Impedance

The value of impedance measured on various tappings shall be as stated in the Schedule and minimum and maximum values where stated in the Schedule A of Requirements shall be guaranteed by the Bidder.

The required positive sequence impedance between HV-LV at 75 deg with 100% rating is 13% with +/- 10 % error ratings.

The Tertiary short-circuit capacity shall not be exceed 1500 MVA, accordingly, the impedance between HV-TV and between LV-TV shall be designed.

4.3.8 Noise

The transformer noise levels shall be measured as a type test and in accordance with IEC 60076-10. The acceptance level of the transformers shall be as stated in the Schedule of Requirements.

4.3.9 Harmonic Suppression

Transformers shall be designed with particular attention to the suppression of harmonic voltages, especially the third, fifth and seventh harmonics, and to minimize the detrimental effects resulting there from.

4.4 MAGNETIC CIRCUIT AND WINDINGS

4.4.1 Magnetic Circuit

The core winding structure and major insulation shall be such as to permit an unobstructed flow of cooling oil over the core and through the core cooling ducts to ensure efficient cooling of the core and where required of flux shunts and tie rods/bars.

The magnetic circuit shall be insulated from core bolts and supporting frame work and be capable of withstanding a test voltage to core bolts and to the frame of 2.5 kV r.m.s for one minute. Two separate insulated removable bolted earthing links shall be provided for earthing of the core and of the core-supporting framework to the exterior of the tank. These links shall be located in a covered box at the top of the transformer and arranged so they are accessible for testing purpose without opening up the transformer. Alternatively connection to both the core and the frame may be made via two externally bolted links within an access box fitted with an oil tight cover near the base of the tank.

The core shall be earthed via copper straps inserted in each group of core

packets separated by oil ducts or other insulating materials: and at a minimum of four (4) points distributed evenly across the width of the core.

4.4.2 Flux Density

Cores shall be constructed from cold rolled grain oriented steel sheets. Design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, and that when operating under the most onerous conditions envisaged in IEC 60076 and IEC 60354, flux density in any part of the magnetic circuit does not exceed 1.9 Tesla.

4.4.3 Windings

i) Construction of Windings

Transformer star connected windings shall have graded insulation as defined in IEC 60076. For 33 kV and below they shall have uniform insulation as defined in IEC 60076. All neutral points shall be insulated to withstand the applied test voltage specified in the Schedule of Requirements.

The windings shall be located in a manner which will ensure that they remain electromagnetically balanced and that their magnetic centres remain coincident under all conditions of operation.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure for such length of time as will ensure that further shrinkage will not occur in service.

The windings and leads of all transformers shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other transient service conditions including external short circuit.

If the winding is built up of sections or of disc coils separated by spacers, the clamping arrangements shall ensure that equal pressures are applied to all columns of spacers.

ii) Tertiary Windings

The tertiary winding of auto transformer shall be adequately rated for the specified load and its average and hot spot winding gradients at the specified load shall not exceed the specified temperature rise for winding average and winding hot spot when added to the mean oil and top oil temperature rises measured during the temperature rise test on the HV and LV temperature rise tests.

The tertiary winding shall further have adequately conductor cross sectional

area and mechanical strength to withstand a through fault on the tertiary terminals and the fault current present in that winding during line to ground fault on the HV and LV phase terminals and without exceeding the maximum permitted current density and temperature rise limits calculated in accordance with IEC 60076-5 Clause 4.1.4.

4.4.4 Internal Earthing

i) General

All metal parts of the transformer, with the exception of the individual core laminations, core bolts and associated individual clamping plates, shall be maintained at some fixed potential.

ii) Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom main core clamping structure shall be earthed by one or more of the following methods:-

(a) by connection through vertical tie rods to the top structure;

(b) by direct metal-to-metal contact with the tank base maintained by the weight of the core and windings;

(c) by connection to the top structure on the same side of the core as the main earth connection to the tank.

iii) Earthing of Magnetic Circuits

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath an inspection opening in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2.5 kV. The link shall have no detachable components and the connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

All insulating barriers within magnetic circuits shall be bridged by means of aluminium or tinned copper strips, so inserted as to maintain electrical continuity.

iv) Earthing of Coil Clamping Rings

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the Transformer as the main earth connection.

v) Size of Earthing Connections

Main earthing connections shall have a cross-sectional area of not less than 80 sq.mm but connections inserted between laminations may have cross-sectional areas reduced to 20 mm^2 when in close thermal contact with the core.

4.5 TANKS AND ANCILLARY EQUIPMENT

4.5.1 Transformer Tanks

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable structural steel of an approved grade to BS EN 10029. The final coat colour of transformers shall be to Munsell 5Y-7/1. The on load tap changer shall be separated inside the main tank of the transformer.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Each tank shall be provided with at least four jacking lugs, and where required, with lugs suitably positioned for transport on a beam transporter. Haulage lugs should also be provided to enable a cable to be used safely for haulage in any direction.

The transformer tank shall be capable of withstanding a full vacuum when empty of oil, without any significant permanent deformation or damage.

All joints, other than those which may have to be broken, shall be welded.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Where cooling tubes are used, each tube shall be of heavy gauge steel welded into the tank sides, top and bottom.

Each tank cover shall be of adequate strength, must not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. Inspection openings shall be provided to give access to the internal connections of bushings, winding connections and earthing links. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection covers shall be provided with lifting handles.

It must be possible to remove any bushing without removing the tank cover.

Pockets shall be provided for a stem type thermometer and for the bulbs of temperature indicators where specified. These pockets shall be located in the position of maximum oil temperature and it must be possible to remove any bulb without lowering the oil level in the tank. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

A ladder shall be provided on one side of the tank as a means for inspection and access to the top of the transformer. The lower section of the ladder shall be equipped with a barrier complete with provision for locking with a padlock.

4.5.2 Conservator Tanks, Breathers and Air Dryers

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system (see also Clause 4.6.1). Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservator tanks shall also be provided with a cleaning door, filling cap, drain valve with captive cap and an oil level indicator with minimum and maximum levels indicated. The normal level at an oil temperature of 25□C shall be indicated and the minimum and maximum levels shall also be correlated with oil temperature markings. The temperature markings shall preferably be integral with the level indicating device.

The pipework between the conservator and the transformer tank shall comply with the requirements of Clause 4.6.1 and a valve shall be provided at the conservator to cut off the oil supply to the tank.

The conservator shall be fitted with an air cell which shall be connected to a silica gel breather of a type which permits the silica gel content to be removed for drying. Due to the climatic conditions at site, this breather shall be larger than would be fitted for use in a temperate climate. All breathers shall be mounted at a height of approximately 1400 mm above ground level.

A completely separate conservator shall be provided for the OLTC. This conservator shall be fitted with: an oil level gauge, a desiccant breather, isolating valves shall be provided for connection from OLTC conservator connection pipe to OLTC and to connection breather, an oil sump drain valve for sump, a filling cap and a removable end plate for inspection and repainting.

4.5.3 Valves

Each transformer shall be fitted with the following valves as a minimum requirement:-

Main Tank

(A) One 50mm bore filter valve located near to the top of the tank.

(B) One 50 mm bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against (A). Where design permits, this valve may be combined with item (C).

(C) One 50mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable. This valve shall also be provided with an approved oil sampling device.

(D) One valve between the main tank and gas actuated relay, complete with bypass facility to facilitate removal of relay and maintain oil flow.

Conservator

(E) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank complete with bypass pipe work for Buchholz relay to facilitate maintenance of the relay.

(F) One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer

(G) 50mm filter and 50mm drain valve where selector switches are contained in a separate tank.

Diverter Switch Tank

(H) One drain valve to be fitted to each tank.

Radiators and Cooler Banks

(I) Valves at each point of connection to the tank and in accordance with Clauses 4.6.2 and 4.6.3.

The two valves (D) and (E) arrangement across the gas actuated relay are to be connected with a oil pipe work bypass facility to facilitate removal of the relay, due to failure etc, and still maintain the oil flow system between the conservator and main tank.

Blank flanges, plates or captive screw caps shall be fitted to all valves and

pipe ends not normally connected in service.

The omission of any, or the provision of alternative arrangements to the above requirements, will not be accepted unless approved in writing by the Employer before manufacture.

4.5.4 Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil resisting synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork, or similar material, or where metal inserts are provided to limit compression.

Gaskets shall be as thin as possible consistent with the provision of a good seal and full details of all gasket sealing arrangements shall be shown on the Plant drawings.

4.5.5 Pressure Relief Device

An approved pressure relief device of sufficient size for the rapid release of over pressure that may be generated in the tank, and designed to operate at a static pressure lower than the hydraulic test pressure, shall be provided. It shall be of the spring operated valve type ("Qualitrol"/Messko or equivalent) and shall be provided with one set of normally open signaling contacts which will be used for trip alarm purposes.

The relief device is to be mounted on the tank cover and is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation. Discharge of oil shall be directed away from the transformer top cover and clear of any operating position.

4.5.6 Earthing Terminals

Two substantial steel flag type terminals having two 14mm diameter holes on 55mm centres shall be located one on either side and near to the bottom of the transformer to facilitate connection to the local earthing system.

4.5.7 Rating, Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to each transformer tank at an average height of 1500mm above the ground level:-

(A) A rating plate bearing the data specified in IEC 76 Part 1. This plate shall also include the short-circuit current rating and time-factor for each winding.

(B) A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 76 Part 1 with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct physical relationship of the terminals.

(C) A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.

Plates are to be of stainless steel or other approved material capable of withstanding the rigours of continuous outdoor service at site.

4.5.8 Nuts & Bolts of Transformer Tanks

All nuts & bolts of transformer shall be stainless steel.

4.6 COOLING PLANT

4.6.1 Cooling Plant General

Radiators and coolers shall be hot-dip galvanized, designed so that all painted surfaces can be thoroughly cleaned and easily painted in situ with brush or spray gun. The design shall also avoid pockets in which water can collect and shall be capable of withstanding the pressure tests specified in Section 13 for the transformer main tank.

The clearance between any oil or other pipework and live parts shall be not less than the minimum clearances stated in the Schedule of Requirements.

4.6.2 Radiators Connected Directly to Tank

Where built-on radiators are used, each radiator shall be connected to the main tank through flanged valves. Plugs shall be fitted at the top of each radiator for air release and at the bottom for draining.

A valve shall be provided on the tank at each point of connection to the tank.

4.6.3 Cooler Banks

Each cooler bank shall be provided with:-

(A) A valve at each point of connection to the tank.
(B) A valve at each point of connection of radiators.
(C) Loose blanking plates for blanking off the main oil connections.

(D) A 50mm filter valve at the top of each cooler bank.
(E) A 50mm drain valve at the lowest point of each interconnecting oil pipe.
(F) A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.
(G) Air release and drain plugs on each radiator.

The omission of any or the provision of alternative, arrangements to the above requirements will not be accepted unless approved in writing by the Engineer before manufacture.

4.6.4 Forced Cooling

The type of forced cooling shall be as stated in the Schedule of Requirements.

Forced cooling equipment for transformers of similar rating and design shall be completely interchangeable, one with the other, without modification on Site.

4.6.5 Oil Pipes and Flanges

All oil piping necessary for the connecting of each transformer to its conservator, cooler banks etc. shall be supplied and erected under this Contract.

The oil piping shall be of approved material with machined flanged joints. Copper pipework is to comply with BS 61.

Dimensions of steel pipes shall be in accordance with BS 3600 and the drilling of all pipe flanges shall comply with BS 4504.

An approved expansion piece shall be provided in each oil pipe connection between the transformer and each oil cooler bank.

All necessary pipe supports, foundation bolts and other attachments are to be provided.

It shall be possible to drain any section of pipework independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

4.6.6 Air Blowers

Air blowers for forced air cooling shall be of approved make and design and be suitable for continuous operation out-of-doors. They shall also be capable of withstanding the stresses imposed when brought up to speed by the direct

application of full line voltage to the motor.

To reduce noise to the practical minimum, motors shall be mounted independently from the coolers or, alternatively, an approved form of anti-vibration mounting shall be provided.

It shall be possible to remove the blower, complete with motor, without disturbing or dismantling the cooler structure framework.

Blades shall be of material subject to approval.

Blower casings shall be made of galvanized steel of thickness not less than 2.6mm (14 S.W.G.) and shall be suitably stiffened by angles or tees.

Galvanized wire guards with mesh not exceeding 12.5mm shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts can not be touched by test fingers to IEC 60529.

4.6.7 Cooler Control

Where forced cooling using multiple small single-phase motors is employed, the motors in each cooling bank shall be grouped so as to form a balanced three-phase load.

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this Contract for automatic starting and stopping from contacts on the winding temperature indicating devices as specified. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor, or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totaling more than 15 kW simultaneously, either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts which may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk, together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors, shall be included in the Contract.

An alarm of indicating “Transformer Cooling Fault” is to be provided and initiated in the event of any ventilation/cooling motor trip, or failure of either main or control supplies.

4.7 VOLTAGE CONTROL

4.7.1 General

Transformers shall be provided with tap changers for varying the effective transformation ratio. Control schemes of on load tap change shall utilize 110V ac centre tap earthed voltage derived from the 415V, 3 phase, 4 wire system. Phase failure relays shall be provided to ensure a secure supply.

Tap winding and On Load Tap Changer shall be installed at High Voltage side to regulate the Low Voltage side within required system voltage maintaining range, which is +/- 10%.

Number and range of taps shall be as called for in the Schedule A of Requirements.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.

Tap positions shall be numbered consecutively, ranging from one upwards. The tap positions shall be numbered so that by raising the tap position the LV voltage is increased.

4.7.2 On-Load Tap Changers

i) General

On-load tap changers shall be **MR Germany or Hitachi Sweden** make or equivalent, comply with IEC 60214-1 and shall be suitable for power flow in both directions. OLTC shall be of sufficient capacity to satisfy the requirements in this specification. The OLTC shall be of Vacuum type.

The OLTC shall be installed inside the main tank.

Only designs which have been type tested in accordance with these standards will be accepted. Tap changers in auto-transformers shall be located at auto point between the HV and LV windings. Then tap changer shall be placed in primary winding side of the Power transformer in order to regulate the secondary winding side operating voltage. It shall operate in

Constant Flux & Variable Voltage (C.F.V.V.) mode. The Variable Flux & Variable Voltage (V.F.V.V.) design for OLTC is generally not acceptable.

Current making and breaking switches associated with the tap selectors or otherwise where combined with tap selectors shall be contained in a tank in which the head of oil is maintained by means completely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, detection of oil surges and provision of alarm or trip contacts will be dependent on the design of tap-changer and be to the approval of the Engineer.

Some of the above mentioned make, viz., MR Germany and Hitachi Sweden make OLTCs are already existed in PGCB's System and their performance is proven. Hence, if the bidder choose to propose OLTCs from other manufacturers, the proposed manufacturer shall have at least thirty (30) years of manufacturing experience of OLTC prior to the date of bid submission with minimum delivery of at least one hundred (100) nos. of similar or higher rating Vacuum type OLTCs over the last ten years outside the manufacturer's own country and the OLTCs similar to or higher rating of the proposed type shall have complete type test report as per relevant IEC standard (IEC 60214-1) from any independent/STL testing laboratory. The bidders shall have to submit relevant documents with their bids.

ii) Mechanisms

The tap change mechanism shall be designed such that when a tap change has been initiated, it will be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement not being completed an approved means shall be provided to safeguard the transformer and its auxiliary equipment.

Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions. For on-load tap change equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

Thermal devices or other approved means shall be provided to protect the motor and control circuit.

A permanently legible lubrication chart shall be provided and fitted inside the tap change mechanism chamber.

iii) Local and Remote Control

Equipment for local, manual and electrical operation shall be provided in a cubicle complying with Section 2. A thermostat controlled anti-condensation

heater is to be provided in the cubicle. Electrical remote control equipment shall also be supplied as specified in the Schedule A - Scope of Work.

The following operating conditions are to apply to the on-load tap changer controls:-

(A) It must not be possible to operate the electric drive when the manual operating gear is in use.

(B) It must not be possible for two electric control points to be in operation at the same time.

(C) Operation from the local or remote control switch shall cause one tap movement only, unless the control switch is returned to the off position between successive operations.

(D) It must not be possible for any transformer operating in parallel with one or more transformers in a group to be out of step with the other transformers in the group. Any deviation in the position of tap changers has to stop further function of the AVR. (Out of step protection)

(E) All electrical control switches and local manual operating gear shall be clearly labeled in an approved manner to indicate the direction of tap changing, i.e. raise and lower tap number.

(F) Emergency stop push-button at local and remote control positions.

(G) WTI & OTI meters on RTCC panel Automation Requirement :
This panel must be integrated with the SAS to check the functional status of the system. Necessary works to facilitate the monitoring of major component and/or activation status shall be performed at site.

iv) Indications

Apparatus of an approved type shall be provided on each transformer:-

(A) To give indication mechanically at the transformer and electrically at the remote control point of the number of the tapping in use.

(B) To give electrical indication, separate from that specified above, of tap position at the remote supervisory point.

(C) To give indication at the remote control point and at the supervisory control point that a tap change is in progress; this indication to continue until the tap change is completed.

(D) To give indication at the remote control point and at the supervisory control point when the transformers operating in parallel are operating out of step.

(E) To indicate at the tap change mechanism the number of operations completed by the equipment.

v) Oil Treatment

Each tap changer is to be equipped with a stationary on-line oil filter facility, complete with time switch control.

4.7.3 Automatic Voltage Control

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

In addition to the methods of control covered by Clause 4.7.2, the following methods shall also be provided.

(A) Automatic Independent - It shall be possible to select automatic independent control for each transformer irrespective of the method of control selected for any other of the associated transformers.

(B) Automatic parallel - It shall be possible to select any transformer for master or follower control.

It must not be possible to operate any tap changer by supervisory, remote or local electrical hand control while the equipment is switched for automatic operation.

4.7.4 Voltage Regulating Relays

Automatic voltage control shall be initiated by a voltage regulating relay of an approved type and suitable for flush mounting. The relay shall operate from the nominal reference voltage stated in the Schedule of Requirements derived from a circuit mounted LV voltage transformer having Class 1.0 or 0.5 accuracy to IEC 60186 and the relay voltage reference balance point shall be adjustable.

The relay bandwidth shall preferably be adjustable to any value between 1.5 times and 2.5 times the transformer tap step percentage, the nominal setting being twice the transformer tap step percentage.

The relay shall be insensitive to frequency variation between the limits of 47Hz and 51Hz. The relay shall be complete with a time delay element adjustable between 10 and 120 seconds. The relay shall also incorporate an under voltage blocking facility which renders the control inoperative if the reference voltage falls below 80 percent of the nominal value with automatic restoration of control when the reference voltage rises to 85 percent of nominal value.

On each transformer the voltage transformer supply to the voltage regulating relay shall be monitored for partial or complete failure. The specified indicating lamp and alarm will be inoperative when the circuit- breaker controlling the lower voltage side of the transformer is open and also that when the tap changer is on control other than automatic control.

The AVR relay shall be fully integrated into the substation automation system and all AVR related operations shall be securely performed from the Substation Automation System. The Substation Automation supplier shall be responsible for integrating the AVR relay.

4.7.5 Remote Control Panels

The remote control panels specified in the Schedule A of Requirements shall be floor mounted sheet steel cubicles of approved type, layout and colour to Munsell notation 5Y-7/1 and shall be provided for each transformer. The control cabinet shall be of weather-proof construction with dip edge over hanging cabinet doors.Cabinet door to have provisions for a padlock. Each door shall be equipped with a holding bar or other mechanism to securely hold the door open at least 110° from the cabinet against winds gusting to 25 miles per hour. Lamp receptacle controlled by a door switch and located remote from control wires. Receptacle shall be for IEC standard medium base lamps. 100W equivalent LED bulbto be supplied.

One (1) 20 Amp, 230 VAC, single phase, wire grounded duplex convenience receptacle(GFI protected) shall be provided in the control cabinet. Weather-shielded, screened breather holes shall be furnished at the top and bottom ofthe cabinet.

The bottom of the control cabinet shall have a removable plate suitable for the Customer's conduit connections. The removable plate shall be 8" x 20" or larger. The dimensions and centerline location of this plate shall be clearly shown on the outline drawing.

Each shall form a complete enclosure with lockable rear doors and shall be fitted with interior lamp, door switch, heaters, cable gland plates for bottom entry of cables and all other equipment to provide the features specified, the standard requirements (which may be varied to suit Manufacturer's design) being as follows:

· Instruments:

– Voltmeter (voltage at the low voltage terminals of the transformer)

– Tap position indicator with integral or separate scale to indicate the no-load (LV) Voltage in kV appropriate to each winding tap.

· Relays:

– Automatic voltage control

· Controls:

– Automatic/Non-automatic voltage control selector switch

– Remote/Supervisory tap change control selector switch

– Pistol grip selector switch with centre zero

– Independent/Master/Follower selector switch

– AVR voltage reference adjuster

· Indications and Alarms:

– Tap change in progress - white lamp

– Tap change out of step - amber lamp

– Tap change incomplete - amber

– Tap change control on "local"

– Tap change control on auto/manual

– Group 1 Air forced cooling equipment running – white

– Group 1 Air forced cooling overcurrent alarm – amber

– Group 2 Air forced cooling equipment running – white

– Group 2 Air forced cooling overcurrent alarm - amber – Forced cooling failure-amber lamp – VT Fail alarm – amber

– Supply voltage to OLTC failure - amber lamp

Remote control schemes shall be entirely suitable for operation with the distance between the transformer and remote control panels as shown on the Specification drawings.

4.7.6 Off-Load Tap Changers

An externally operated DETC shall be provided for the high voltage winding taps.The off-circuit tappings as specified in the Schedule of Requirements shall be provided on the higher voltage windings for a variation of no-load primary voltage as specified.The DETC shall include tap positions as described in the Appendix section. All taps shall be full capacity taps.

A positive type position indicator shall be furnished, complete with provisions for padlocking the DETC in any on-tap position with padlocks having 3/8" shanks and 2" x 2" x 7/8" bodies. A suitable weather shield shall be provided over the padlock and positioning pin and shall be designed to eliminate the need for tools for access. Any exposed portion of the mechanism, such as a position indicator or geneva gear, shall also be furnished with a weather shield.Off-load tap-changing shall be carried out by means of an external hand-operated tapping switch mounted on the side of the tank. All phases of the tapping switch must be operated by one hand wheel.

All DETCs on a transformer shall be operated by a suitable single external manual handle device, conveniently and safely operable from the ground, with the handle no more than 3 to 5 feet above the tank base. Multiple DETC operating handles are not acceptable.

The DETC operating handle is to be readily accessible for operation without interference from adjacent parts. All taps shall be rated for loading above maximum nameplate capabilities of the transformer as specified in Data Sheets.

Any shaft penetration designs directly through the tank wall at a location below the top of the core/coil assembly shall have double sealing on the rotating shaft and on the mounting flange.

Under no conditions shall a sprocket and chain drive arrangement be acceptable for connecting the DETC assemblies on each phase to the common operating shaft.

The tapping switch shall have a spring-loaded captive bolt or other approved means on the moving part that positively locates the switch correctly at each tapping position. This bolt must be lockable at each tapping position and shall be provided with a suitable padlock and keys. Moving the switch from one tapping position to another shall require that the bolt be withdrawn by hand from its locating socket on the transformer tank against the spring pressure.

Tap-position numbers corresponding to the tapping switch bolt-locating sockets shall be cast or engraved in a metal indication plate fixed to the tank and a keyed metal pointer on the tapping switch operating handle shall show clearly at which tapping number the transformer is operating.

All tap-position indicators shall be marked with one integer for each tap position, beginning at number 1. Adjacent taps shall be numbered consecutively in such a manner that when moving a tap to a new tapping position that has a higher number, the no-load output voltage of the untapped winding increases.

DETCs shall be prevented from being left between taps and shall be prevented from moving off tap due to vibrations or bumping.

All tapered pins used in DETC assemblies shall be fully driven into the holes, slightly below the surface of the entrance side of the holes, and the entrance side of the holes deformed.

4.8 SUPERVISORY CONTROL

4.8.1 Requirements

Transformer tap change control will be effected from the substation control room with facilities for remote control from the Load Dispatch Centre. All necessary connections, indications, auxiliary switches, relays and changeover switches to meet supervisory control requirements shall be provided and connected under this Contract to terminal blocks in the remote control panels. The supply and installation of the multicore control cables

between the remote control panels and the Plant/Telecontrol Interface Cubicle shall be provided under the Contract.

The following supervisory facilities are required:

Controls:

i) Supervisory selection of auto/non auto voltage control.
ii) Tap change raise/lower by direct operation of tap changer.
iii) Tap change blocking on/off.
iv) Remote/Supervisory selection "Override".
v) Parallel/Independent control.

Indications and Alarms:

i) Tap position indication
ii) Tap change out of step alarm
iii) Buchholz and winding temperature non-trip alarm
iv) Tap change control on Local/Supervisory
v) Parallel/Independent, master/follower
vi) Tap change blocking on/off
vii) Tap change control on Automatic/Manual

All contacts for supervisory alarms and indications shall be potential free.

4.9 TERMINAL BUSHINGS AND CONNECTIONS

4.9.1 Bushings

All bushings shall be Resin Impregnated Paper (RIP) bushings oil-free dry and clean technology. All terminal bushings (unless otherwise noted on the Specific Transformer Data Sheet) shall be located on the tank cover and shall be in accordance with IEC Standards where applicable.

For quality, reliability and maintenance requirements the bushings shall be supplied from Hitachi (Sweden), Trench (France/USA), HSP (Germany), GE (Italy) (and as specified in Technical data sheets) or equivalent.

All bushings shall be designed, manufactured and tested such as routine, special and type testing according to all requirements of latest edition in IEC 60137 and in accordance with stipulation in sub-clause no. 3.4.11 of Section-3 of this specification.

Some of the above mentioned make, viz., Hitachi (Sweden), Trench (France/USA), HSP (Germany) & GE (Italy) make bushings are already existed in PGCB’s System and their performance is proven. Hence, if the

bidder choose to propose bushings from other manufacturers, the proposed manufacturer shall have at least thirty (30) years of manufacturing experience of Resin Impregnated Paper (RIP) bushings prior to the date of bid submission with minimum delivery of at least three hundred (300) nos. of similar or higher rating Resin Impregnated Paper (RIP) bushings with silicon composite housing over the last ten years outside the manufacturer's own country and the bushings similar to or higher rating of the proposed type shall have complete type test report as per relevant IEC standard (IEC 60137) from any independent/STL testing laboratory. The bidders shall have to submit relevant documents with their bids.

Where called for in the Schedule of Requirements, space and fixtures shall be provide for accommodating current transformers and the bushings shall be so arranged that they can be removed without disturbing the current transformers, secondary terminals and connections.

Typical sections of bushing insulators, showing the internal construction, method of securing the top cap and methods of sealing or breathing shall be submitted with the Tender.

4.9.2 N/A

4.9.3 Cable Boxes

Where specified in the Schedule of Requirements, transformers shall be provided with cable boxes, which shall be complete with all necessary fittings.

Cable boxes shall be of adequate proportions and designed in accordance with BS6435 in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cables.

Cable boxes shall be designed for ease of access for jointing and connecting the cable. They shall be constructed to minimize the danger of fragmentation; cast iron boxes shall not be used.

Cable boxes shall be of such a design as to prevent ingress of moisture. Where blind tapped holes have to be provided, studs shall be used and not bolts or set screws.

Where gaskets are used, they shall be of synthetic rubber/cork composition or approved material. All gaskets, unless otherwise approved, shall be in one continuous piece without joints. Gaskets shall not be compressed before use.

Provision shall be made for earthing the body of each cable box.

Removable blank gland plates shall be supplied and shall be drilled with 9 mm pilot holes. Cable glands shall be supplied and fitted.

Draining holes protected by l mm aperture mesh shall be incorporated at the base of the box to ensure drainage of condensation.

Cable boxes shall be provided with suitable means for clamping the armour wires of the cables.

Gland plates for single core cable shall be made from non-ferrous metal.

The Bidder shall guarantee (test certificate shall be supplied to prove) that the air clearances and the creepage path on the bushing connecting to the associated transformers shall be such that the completed installation shall withstand in air the impulse and power frequency voltages appropriate to the plant.

Where specified, an oil-filled cable disconnecting chamber with removable links shall be provided for testing purposes. Barriers shall be provided on both sides of the disconnecting chamber to prevent ingress of the oil used for filling the chamber into the cable box or the transformer. It must only be necessary to remove part of the oil in the chamber itself when making the necessary testing connections.

The disconnecting chamber shall have a removable cover and the design of the chamber is to be such that ample clearances are provided to enable each cable to be subjected separately to high voltage tests.

The oil level in the disconnecting chamber shall be maintained from the main conservator tank by means of a connection to the highest point of the chamber and this connection shall be controlled by suitable valves. The connection to the conservator shall be made so that any gas leaving the chamber must pass through the gas and oil-actuated relay.

An earthing terminal shall be provided in each disconnecting or sealing end chamber, to which the connections from the transformer winding can be earthed during cable testing.

4.9.4 Open Air Terminal Bushings

Unless otherwise specified the windings of the transformer shall be terminated through open air bushings.

The bushing shall include all connectors clamps complete with stainless steel bolts, nuts and washers necessary for connections to conductors.

Full details of the design of the bushing, palms, flanges, connectors and

connections, etc. at the transformer end shall be subject to the Employer's approval.

4.9.5 Tertiary and Neutral Terminations

Terminations of delta connected tertiary windings and neutral ends of windings shall be as follows;

a) Delta Connected Tertiary Windings

Delta connected tertiary windings for local AC distribution shall be terminated as open air terminal bushings.

Where current transformers are specified in the Schedule of Requirements or on the Drawings, these shall be included on this Contract.

b) Neutral Ends of Windings

Neutral ends of the three phase windings shall be connected at a point accessible from a handhole at the transformer tank top cover. Where current transformers are specified at the neutral ends before the neutral connection of the windings, to be used in conjunction with a protection, they shall be installed such that access is possible through the same handhole and maintenance of these CT, if need be, can be carried out without lowering the transformer oil below the core and winding.

The star connection shall then be brought out via one outdoor bushing insulator capable of withstanding an AC power frequency test.

4.9.6 Mounting of Bushings

Bushing insulators shall be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Neutral bushings shall be mounted in a position from which a connection can be taken to a neutral current transformer mounted on a bracket secured to the transformer tank.

The clearances from phase to earth must not be less than those stated in the Schedule A of Requirements.

A flexible pull-through lead suitably sweated to the end of the winding copper shall be provided for the bushings and is to be continuous to the connector which is housed in the helmet of the bushings.

When bushings with an under-oil end of a re-entrant type are used the associated flexible pull-through lead is to be fitted with a suitably designed gas bubble deflector.

The bushing flanges must not be of re-entrant shape which may trap air.

Clamps and fittings made of steel or malleable iron shall be galvanized and all bolt threads are to be greased before erection.

4.9.7 Bushing Current Transformer (BCT)

BCT shall be mounted at HV, LV, TV and Neutral Bushing, and installed numbers and particulars are stated in the Schedule A volume 3 of 3 (Schedule of Requirements).

4.10 AUXILIARY POWER AND CONTROL CABLES

4.10.1 Scope of Supply

This Contract includes the supply, installation and termination of the necessary auxiliary power and control cables within items of plant supplied under the Contract.

The Bidder shall produce, during the currency of the Contract and in any case before shipment of plant commences, detailed cable core schedules for each transformer.

4.10.2 General

Auxiliary power and control cables shall have copper conductors, PVC insulated, armoured and PVC sheathed overall. The cable design shall generally be in accordance with BS 6346 and Section 6 of this Specification.

All cables installed under the Contract shall utilize compression glands of type E1 to BS.6121 or otherwise designed to secure armour wires and bond them to earthed metal and to provide seals between sheath and gland and between inner sheath and threaded fixing component.

The Bidder shall supply and fit the compression gland and make off individual cores on to the terminal boards, including the supply and fitting of numbered markers on each core.

4.11 TEMPERATURE AND ALARM DEVICES

4.11.1 Temperature Indicating Devices and Alarms

The transformers shall be provided with approved devices of Kilhstrom or equivalent for indicating the top oil temperature and hottest spot winding temperatures. The devices shall have a dial type indicator and, in addition, a

pointer to register the highest temperature reached. Each winding temperature device shall have three separate contacts fitted, one of which shall be used to control the cooling plant motors, one to give an alarm and one to trip the associated circuit-breakers.

To simulate indication of the hottest spot temperature of the winding the device shall comprise a current transformer associated with one phase only and a heating device designed to operate continuously at 130 percent of transformer CMR current and for 30 minutes at 150 percent of CMR current, associated with a sensing bulb installed in an oil tight pocket in the transformer top oil.

The winding temperature indicators (WTI) shall be housed in the marshalling cubicle. The tripping contacts of the winding temperature indicators shall be adjustable to close between 80°C and 150°C and to re-open when the temperature has fallen by not more than 10°C.

The alarm contacts and the contacts used to control the cooling plant motors on the above devices shall be adjustable to close between 50°C and 100°C and to re-open when the temperature has fallen by a desired amount between 10°C and 15°C.

All contacts shall be adjustable to a scale and must be accessible on removal of the relay cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 volts and 250 volts AC or DC and of making 500 VA between the limits of 110 and 250V DC. Cooler motor control contacts shall be suitable for operating the cooler contactors direct or, if necessary, through an interposing relay.

The temperature indicators in the marshalling kiosk shall be so designed that it is possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.

The working parts of the instrument shall be made visible by the provision of cut-away dials and glass-fronted covers and all setting and error adjustment devices shall be easily accessible.

Connections shall be brought from the device to terminal boards placed inside the marshalling cubicle.

Terminals, links and a 63mm moving iron ammeter shall be provided in the marshalling kiosk for each WTI for:-

(A) Checking the output of the current transformer.

(B) Testing the current transformer and thermal image characteristics.

(C) Disconnecting the bulb heaters from the current transformer secondary circuit to enable the instrument to be used as an oil temperature

indicator. Links shall be provided as shown on the drawing enclosed with this Specification.

4.11.2 Gas and Oil-Actuated Relays

Each transformer shall be fitted with gas and oil-actuated relay equipment having alarm contacts which close on collection of gas or low oil level, and tripping contacts which close following oil surge conditions.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

Each relay shall be fitted with a calibrated glass window for indication of gas volume.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1400mm above ground level, where it shall be terminated by a cock which shall have provision for locking to prevent unauthorised operation.

The design of the relay mounting arrangements, the associated pipework and the cooling plant shall be such that maloperation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps, whether by manual or automatic control under all operating temperatures.

The pipework shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipework shall be avoided.

For two conservators piped separately to the transformer, one Gas and Oil actuated relay shall be installed in the main tank and an Oil-flow relay shall be installed in the OLTC conservator.

4.12 SHIPMENT AND DRYING OUT

4.12.1 Shipment

Each transformer, when prepared for shipment, shall be fitted with a shock indicator or recorder which shall remain in situ until the transformer is delivered to site. In the event that the transformer is found to have been subjected to excessive shock in transit, such examination as is necessary shall be made in the presence of the Engineer.

Where practicable, transformers shall be shipped with oil filling to cover core and windings but, when shipped under pressure of gas, shall be fitted for the duration of delivery to site and for such time thereafter as is necessary, with a gauge and gas cylinder adequate to maintain internal pressure above atmospheric.

4.12.2 Drying Out

All transformers shall be dried out by an approved method at the manufacturer's works and so arranged that they might be put into service without further drying out on Site.

Clear instructions shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barriers or tank cover) which must be taken before the specified vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand the treatment shall be provided with each transformer.

4.13 TRANSFORMER OIL AND TREATMENT

4.13.1 Transformer Oil

The Bidder shall supply the first filling of all insulating oil required for the operation of the Plant and, after treatment, a test shall be made in the Engineer's presence to prove that the breakdown voltage is at least 50kV at 2.5mm electrode gap. The transformer oil shall be new, inhibited, naphthenic based mineral oil, free from additives. It shall be acid-refined and pre-treated and shall have properties complying with IEC 60296-class II.

4.13.2 Oil Storage

As required by Clause 4.13.1, the Bidder shall supply the first filling of transformer oil to site in via bulk tanker or supplied in bulk packaging.

4.14 EARTHING/AUXILIARY TRANSFORMERS

4.14.1 General

Earthing transformers shall comply with IEC 60076-6 and shall be of the oil immersed ONAN type suitable for outdoor installation. They are to have a main interconnected zig-zag winding for primary and star winding for secondary brought out via oil/air terminal bushings, which will be directly connected to the lower voltage terminals of the associated system transformer.

The neutral point of the interconnected star winding shall be brought out of the tank through a bushing insulator. This point maybe isolated or connected to earth directly or through a resistance in order to provide an earthing point for the neutral of the system.

The earthing transformers shall have a secondary winding to supply the substation auxiliary load. The voltage ratio shall be 33/0.415 kV. The star-connected secondary windings shall be arranged to give a three-phase, four wire supply with the star point solidly earthed. The secondary winding shall have a continuous rating of 500 kVA or as stated in the Schedule of Requirements and shall conform to IEC 60076.

4.14.2 Electrical and Short Circuit Characteristics

Earthing transformers will normally have their neutral points connected to earth via a resistance which limits earth fault current to the full load current at the associated power transformer. However, provision is made for solidly earthing the neutral points and, under this condition, the earthing transformers shall be capable of withstanding, both thermally and mechanically without damage, for a period of 5 seconds the application of normal three phase line voltage to the terminals of the interconnected star winding with one line terminal earthed. The current density of the winding under this condition shall not exceed 50A/mm^2.

In addition, the interconnected star winding of each earthing transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for 10 seconds without injurious heating an earth fault current in the neutral connection as specified. The current density under such conditions shall not exceed 23A/mm^2.

4.14.3 Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

(A) Conservator vessel with removable end cover and prismatic oil gauge.
(B) Buchholz relay.
(C) One thermometer pocket with captive screw cap.
(D) Silica gel breather of the oil seal type.
(E) Pressure relief device.
(F) Filter valve and combined filter and drain valves.
(G) Oil sampling device.
(H) Rating plate.
(1) Tank earth terminals.
(J) Lifting lugs.

4.14.4 Secondary Windings

The three-phase, four-wire secondary windings shall be terminated at a three-pole MCCB unit with bolted neutral link and gland entry for a four-core solid dielectric cable. This shall be accommodated in a lockable, fully weatherproof compartment together with a neutral earthing link. The purpose of the neutral earthing link is to connect the 400 V system neutral to earth. It shall be connected between the transformer winding end and a suitably located earthing terminal to which the system earth can be connected.

The windings shall be fitted with off-load tap changer to vary the voltage ±5 percent of the nominal open circuit value in 2.5 percent steps.

4.14.5 Terminal Connections

The 33 kV side of the earthing transformers shall be fitted with oil/air terminal bushings. The earth point connection to the neutral earthing resistor shall be via a 33 kV conductor.

4.15 N/A

4.15(N) TRANSFORMER CONTROL AND MONITORING

Transformer Control and Monitoring system shall be integrated and operated in the Substation Automation system based on IEC 61850 standards. The IEDs for Control and Monitoring shall be mounted in the transformer bay-unit, it shall be independent from protection IEDs. Transformer bay unit shall be located in the Local Control House, while the Local Control Panel of the transformer attached to the Transformer. Protection BU and Control & Monitoring BU shall be installed separately. Also control and monitoring function shall be properly allocated within separate IEDs to ensure dependability.

AVR shall be installed within the Transformer Protection and Control Bay Unit, and the status shall be monitored at Substation HMI.

All function and units of each transformer shall be monitored and controlled at substation HMI by a specialized graphical application of the substation automation system.

All information shall be properly collected and be transmitted to NLDC. Based on tap position and voltage information, OLTC shall also be controlled at NLDC.

Items required to be controlled for transformer are as stated below but are not limited to the following;

- AVR operation, OLTC operation, cooling fan control, etc

Items required to be monitored for transformer are as stated below but are not limited to the following;

Temperature (Top oil, Ambient, Winding hot spot, Bottom oil, etc), Cooling

system (Fan or pump failure, Cooling contact failure, etc), On-load tap changer (Tap position, Tap counter, etc), Oil Level, Mechanical relays & devices and AVR status.

4.16 Transformer Online Dissolved Gas Analyzer (DGA) (NOT APPLICABLE)

Online Dissolved Gas (Multi-gas) and Moisture Analyzer

a) Online Dissolved Gas (Multi-gas) and Moisture Analyzer (if specified in BPS) along with all re- quired accessories shall be provided with each transformer for measurement & analysis of dis- solved gases and moisture in the oil Interpretations shall be as per IEC 60599-1999.

b) The equipment shall detect, measure and analyze the following gases:

SL	Gases & Moisture Parameters	Typical Detection Range
1	H2	5 – 3,000 ppm
2	CH4	5 – 5,000 ppm
3	C2H6	5 – 5,000 ppm
4	C2H4	3 – 5,000 ppm
5	C2H2	1 – 3,000 ppm
6	CO	10 – 10,000 ppm
7	CO2	20 – 30,000 ppm
8	O2	500 – 25,000 ppm
9	H2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

c) The analyzer should measure (not calculate) all above gases and should have100% sensitivity. The equipment shall be IEC 61850 compliant to integrate with SCADA system. The results shall be communicated to control room or remote location (through SCADA) and shall be compared with the standard preset results to indicate the possible severe damage/failure.

d) Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

e) Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

f) Online DGA shall be installed out door on transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). The equipment shall be suitable for proper operation in EHV substation(800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55Stainless Steel enclosure, suitable for 55oC ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of two (2) years manufacturer's Warranty.

g) The equipment shall connect to the transformer's main body in two locations. One connection is for the supply of oil from the transformer. Second connection is for the return of the oil to the transformer. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.

h) The equipment shall be able to measure gas concentration and when downloaded should immediately compare it with user selected alarm & caution level for immediate display. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval.

i) The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if any- thing required including cylinder must be mounted with the Equipment.

j) The technical feature of the equipment shall be as under:

Accuracy + 10%
Repeatability +3% to 10%
depending upon gases Oil
temperature range - 200 C to +
1200 C External Temp. Range -
200 C to + 550 C Humidity
range 10 to 95 %
Operating Voltage 230 Vac; 50 Hz (±20% variation)
Communications USB & IEC 61850 compliant

k) Software for fault indication and fault diagnostics shall include following:

Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending Fault Diagnosis:
i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

l) The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Troubleshooting in- structions.
v) Basic 8 Gas Monitor with Monitor Mounting Kit
vi) Calibration Cylinder
vii) Bleed Fixture & Junction Box with 3.5ft. Cables
viii) Carrier gas tank regulator, dryer and supply lines
ix) Load Guide & Ambient Temperature Sensors
x) Manual DGA sample port assembly
xi) Oil supply and return assembly

xii) Associated Software
xiii) Carrier Gas Cylinder with 99.999% purity with gas regulator and pressure gauges
xiv) Suitable SS Tubing of required dia and length for oil & gas
xv) Moisture Probe for monitoring Moisture
xvi) xvi) Any other accessories required for with the supplied item other than what is specified.

4.17 INSPECTION AND TESTING

Inspection and testing of transformers during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.

4.18 FIRE PROTECTION SYSTEM

4.18.1 General

This Sub-clause covers the design and performance requirements of :

Water Spray type Fire Fighting for the 230/132/33KV 225/300MVA ONAN/ONAF & 132/33kV 80/120MVA ONAN/ONAF transformer.

It is not intended to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Employer. The system design shall also conform to TAC/ NFPA norms.

The system offered shall comply with the relevant International Standards, conforming to any other approved international standards shall meet the requirements called for in the latest revision of relevant International Standard.

Ambient temperature for design of all equipment shall be considered as 45°C.

The system shall be reliable without making any mal operation. Even if undesirable nitrogen gas injection is made into the transformer tank under normal transformer condition without the internal faults, restoration of transformer by vacuum oil purification up to re-energizing shall complete as soon as possible after the undesired gas injection.

In case of an event of the control power failure, the system shall be able to be operated manually.

Various equipment to perform the required fire protection shall be provided

under this Contract.

Reference of standards is listed below. Relevant International Standards other than BS standards shall be subject to approval by the Employer:

BS Standards

BS 381 C	Colours for Identification, Coding & Special Purpose
BS 7629-1	Specification for 300/500 V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire.
BS 8434-1	Methods of test for assessment for power integrity of electric cables
BS 5839-1	Code of practice system design, installation, commissioning and maintenance for fire detection and fire alarm system

BS EN50267-2-1 Common Test Methods for Cables Under Fire Conditions

4.18.2 WATER SPRAY SYSTEM

The 230/132/33KV 225/300MVA ONAN/ONAF & 132/33kV 80/120MVA ONAN/ONAF network transformer are to be equipped with the arrangements specified below:

One transformer water spray system.

To the water spray system is to be allowed one valve station including necessary control and monitoring cabinet, to be designed for manual, automatic and electrical remote operation and must be provided in free-standing and self-supporting design, with the following basic equipment:

- the required number of triggering and fire extinguishing nozzles, with galvanized pipes and mountings,
- the necessary galvanized connecting lines from the appropriate valve station to the nozzles pipe network,
- the necessary drainage valve, struts, diaphragms, sleeve valve, single chamber valve stations with all fittings and connections, pressure sensitive switches for signalling and air pressure drop with the possibility of extension by three transformer,
- the necessary tank feed pump,

- pressurizing air vessel for maintaining a reserve of fire-fighting water,

The pressurizing air vessel is to be designed for a minimum spraying time of 5/20 minutes and is to be fully equipped with all necessary fittings and connecting pipes, pressure controllers, low water level alarm, reducing valves and all other equipment essential for trouble-free operation.

The pressurizing air vessel is to be installed above ground.

Two air pressure units, rated pressure 10 bar, each provided with the following main equipment:

- 1 air compressor
- 1 400/230 V three-phase motor
- 1 flexible coupling
- 1 oil and water separator
- 1 non-return valve
- 1 vent and drain valve
- 1 pressure gauge

install complete on a sturdy base frame with all necessary anti-vibration mounts and fixing material.

One compressed air container, 1000 1, vertical type, welded with manhole, rated pressure matched to the water spray system including the following main fittings:

- 1 contact type pressure gauge
- 1 relief valve
- 1 pressure switch
- 1 drain valve

assembled completely and ready for operation, the volume of air being matched to the time sequence of the transformer extinguishing operation.

The necessary control cabinet, enclosure type IP 55, completely equipped with the following main items:

2 motor-protection switches, 400/230 V, 50 Hz coil voltage 230 V 50 Hz,

auxiliary contactors and relays for optional operation of compressors 1 and 2 with switch controlling operation.

Positions:

Manual 1- manual 2-0-auto 2

With terminal board and cable entry glands as well as the necessary local fault and indicator lamps and spare contacts for remove monitoring and the necessary interlock criteria.

One complete compressed air distribution system with the necessary signaling pressure gauges, contact pressure gauges, pressure relief valves, pressure gauge valves, drain valves, pressure reducing valves, hand-operated shut-off valves and copper piping in the diameters required for the compressed air distribution.

Automation Requirement :

The WSS must be integrated with the SAS to check the functional status of the system. Necessary works to facilitate the monitoring of major component and/or activation status shall be performed at site.

4.18.3 Compressed Air Foam System (CAFS) (NOT APPLICABLE)

When required by the schedule of requirement, the Contractor shall provide the CAFS (Compressed Air Foam System) arrangements specified below:

The Compressed Air Foam System design shall also conform to NFPA 11.

The compressed air foam system shall be provided with selection valve station including the necessary control and monitoring cabinet to be capable of extension to serve in total of transformer units in each substation.

The compressed air foam system is to be designed for manual, automatic and electrical remote operation and must be provided in the package type and equipped inside house (with temperature control system to protect itself from the external environment), with the following basic equipment:

Water tank and Foam concentrate tank shall be installed and pre-mixed foam system is not accepted. Fire water and Foam concentrate is stored separately, and water driven type foam proportioning unit shall be installed.

CAFS Package includes:

- PLC based CAFS Control Panel
- Foam Proportioning unit : water turbine drives a positive displacement foam concentrate pump. Ratio 3%
- CAF Mixing Chamber Unit : Foam Solution to Air Ratio = 1:7
- Compressed Air Cylinder Unit : Compressed air cylinders pressurized to 200 bar. Each cylinder is supplied with a cylinder valve equipped with a safety relief disc which provides relief at 300 bar.
- And cylinder valve should be closed normally. The method of open the cylinder valve should be electromagnetic two actuators (main and stand-by), not CO2/N2 actuating unit. (for reliable, open operation)
- Air pressure regulators are used to reduce the air pressure to a working pressure for the CAF system operation. The cylinders unit is factory assembled on a painted steel skid and includes regulator box with stainless steel for safety protection.
- Water Storage Tank : Water storage tank stored inside a normally non-pressurized stainless steel pressure vessel type tank stamped according to ASME Section VIII Div. 1.
- Storage tank maximum working pressure is 10 bar. The tank is supplied with a safety relief valve for protection against over-pressurization and also with a two-points level switch. (1st point : Low-level alarm when water less than required, 2nd point : A spraying CAF is stopped automatically when running out of water)
- Foam Concentrate Storage Tank : Stainless steel atmospheric pressure tank
- No Pre-mixed type : Foam solution should be made with Foam Proportioning unit.
- Internal stainless steel pipe & valves, instruments shall be double-structured.
- CAFS control panel : for manual, automatic and electrical remote operation.
- The UPS shall be built in CAFS control panel.

<Other components>

The required number of CAF nozzles

The required number of selection valves

The required amount of foam concentrate (AFFF 3%)

The required CAF discharge rate shall be 1.63 lpm / m2 (foam solution). The required CAF volume shall be considered for spraying for any one unit of the power transformers.

The compressed air foam system is to be designed for a minimum spraying time of 10 minutes and is to be fully equipped with all equipment essential for trouble-free operation.

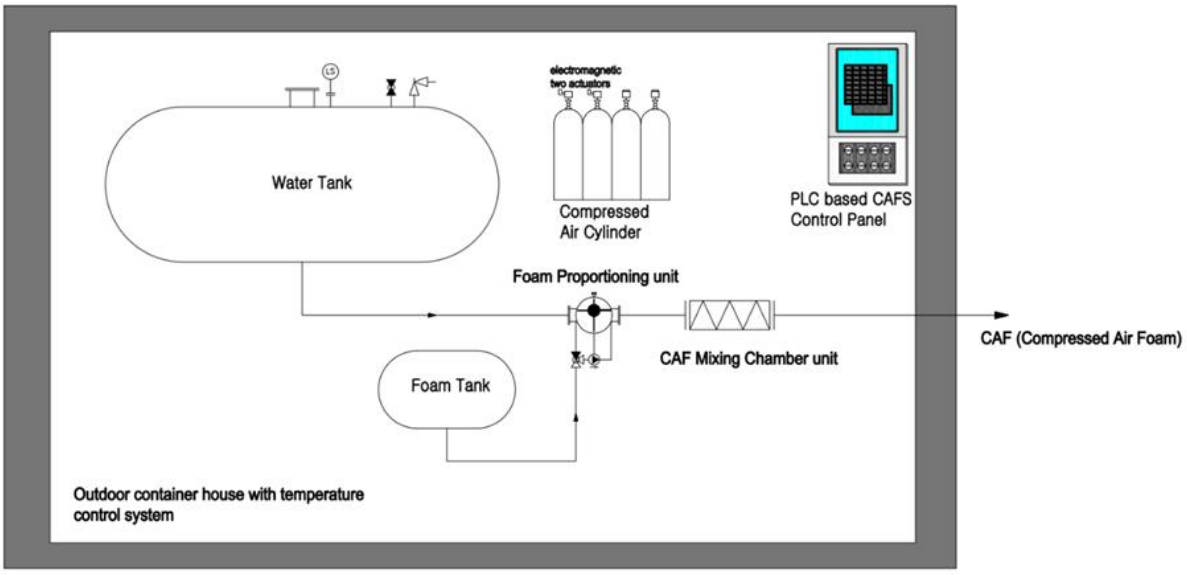
In the event of a fire by external causes such as bushing fire, OLTC fires, fire from surrounding equipment etc., it shall act as a fast and effectively.

For quality and maintenance requirements, the Compressed Air Foam Systems (CAFS) shall be from Europe/USA/Canada/Korea/Japan origin. And the supplier of CAFS must have a delivery record (including installation) of CAFS for more than ten (10) power transformers (over 50MVA each) within the last three (3) years.

Automation Requirement

The CAFS must be integrated with the SAS to check the functional status of the system. Necessary works to facilitate the monitoring of major component and/or activation status shall be performed at the site.

<Reference Drawing>



POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 5

SUBSTATION AUTOMATION
(Protection, Metering and Control)

SECTION 5
SUBSTATION AUTOMATION SYSTEM
Protection, Metering and Control

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SECTION 5
SUBSTATION AUTOMATION SYSTEM
Protection, Metering and Control

5.1 General

The protection and control facilities shall be suitable for the power system arrangement as shown on the Single Line Drawing and Trip Logic provided with the bid document.

5.1.1 For each substation, the Contractor has to foresee one (or more) separate cubicle(s) for:

- Control system – SCADA Server (Control, SCADA, SAS, etc.)
- Operator's Working Station
- Gateway server
- DFDR
- AVR
- Protection system
- Metering
- 33 kV Control cubicle(s)

During the Design stage, the Contractor has to propose the final solution, which will be subject of the Employer's final approval.

5.1.1.1 The Main 1 & Main 2 relays of the same protected object shall be from different manufacturers or different model from the same manufacturer.

5.1.1.2 During the Design stage, the Contractor can propose different arrangement like:

- Main 1 Protection and Main 2 Protection in the same cubicle and separate Control cubicle or
- Both Protection and Control in the same cubicle for lower voltage class like 132kV & lowers

5.1.1.3 The final solution will be subject of the Employer's final approval. However, the bidder/manufacturers of relay shall provide at least 5 years of warranty for its product, i.e., for complete Protection system.

5.1.1.4 During the design and execution stage, the contractor shall submit the GTP of the panel (annexure 1) for approval and must also adhere to the employer's requirements for manufacturing all panels as per annexure 2.1 and annexure 2.2.

5.2 Protection Relay - General

5.2.1 For standardization of operating performance, facilities and spare requirements, the protection relays and control systems, together with complete panels to be supplied under this project shall be manufactured by Hitachi (Switzerland/Sweden), Alstom/GE (France/UK/USA), Siemens (Germany), SEL (USA/UK/Canada), NR Electric (China) or equivalent. Since some of the above mentioned make, viz., Hitachi (Switzerland/Sweden), Alstom/GE (France/USA/UK), SEL (USA/UK/Canada), NR Electric (China) and Siemens (Germany) make Protection Relay and Substation

Automation System (SAS) are already existed in PGCB's System and their performance is proven, only Manufacturer's Authorization letter among the Qualification Criteria of clause 2.6 of Section 3 of volume 1 of 3 of the Bidding Document is required to be submitted with the bid of the bidders who choose to propose Relay & SAS from these proven manufacturers. Acceptance of any other Relay, control system and SAS with similar characteristics shall have to fulfil the Qualification Criteria of clause 2.6 of Section 3 of volume 1 of 3 of the Bidding Document.

5.2.2 The protection shall be sufficiently sensitive to cater for the minimum fault level condition. This will be advised later. The protection shall also be suitable for a system fault level equal to the switchgear rating as mentioned in section 1 of this specification for all voltage system. All current transformer design shall be based on these fault levels.

5.2.3 All relays shall operate correctly within system frequency limits of 47Hz to 51Hz.

5.2.4 Installation, testing and commissioning of Control, protection and metering system shall be done by the Manufacturer(s) Engineer(s).

5.2.5 All the Auxiliary relays (Contactor, TCS, Tripping relays, thermostat, humidity controllers etc.) used for protection scheme shall be of Europe/USA origin or from any eligible country with equivalent quality.

5.2.6 Since some of the above mentioned make, viz., ABB (Switzerland/Sweden), Alstom/GE (France/UK/USA), Siemens (Germany), NR Electric (China), SEL (USA), relay and control system is already existed in PGCB's System and their performance is proven, only Manufacturer's Authorization letter among the Qualification Criteria of sub-clause 2.6 of Section 3 of volume 1 of 3 of the Bidding Document is required to be submitted with the bid of the bidders who choose to propose Relay & SAS from these proven manufacturers. Acceptance of any other relay, control system and SAS with similar characteristics shall have to fulfill the Qualification Criteria of sub-clause 2.5 of Section 3 of volume 1 of 3 of the Bidding Document.

5.3 Fault Clearance Times

5.3.1 400kV, 230 kV, 132 kV and 33 kV systems overall fault clearance times (i.e. from fault initiation to arc extinction) shall not exceed the following:

Type of Fault		Maximum Fault Clearance Time			
Nominal system voltage between phases	kV	400	230	132	33
Substation and transformer fault	msec.	80	100	120	300
Line faults:					
Up to 72% of the line length (i.e. 90% of a distance relay zone 1 reach setting of 80% of the line impedance)	msec.	80	100	120	300
72% of 100% of the line length where (@) plus protection signalling time	msec.	100	130	150	300

5.3.2 These requirements must be fulfilled under all system conditions including maximum dc current offset and any time delay. Clearance within these times shall be achieved for all types of faults except high resistance earth faults detected by DEF protection or under circuit breaker failure conditions.

5.4 Arrangement of Facilities

5.4.1 Control and relay equipment shall be mounted on panels and cubicles as specified and shall be installed in permanent buildings on the substation sites. The order of the panels shall follow the sequence shown on the drawings. Sufficient protection from external disturbances must be established for the Control, Protection and SAS equipments. Control cables should be properly armoured; sealing must be provided at the entrance of the respective panel.

5.4.2 Panels provided as extensions or for erection in the same room as existing panels shall be of similar design and appearance to those existing. Equipment, meters, etc., mounted on such panels shall likewise be of style and scaling similar to the existing equipment. Characteristics of relays, etc., and all connections of equipment to be associated with existing equipment shall be such that they are fully compatible with and can operate satisfactorily in conjunction with the existing equipment. The characteristics and appearance of all such equipment shall be to the approval of the Engineer.

5.4.3 Backup Control panels shall incorporate all necessary control and indication facilities along with hardware based interlocks for the operation of the devices at the associated substation even in the case of failure of Substation Automation System. In addition, the substation may be remotely controlled and supervised from the National Load Dispatch Centre (NLDC) in Dhaka. Necessary NLDC integration must be performed by the contractor.

5.4.4 The Gateway system for communication to the NLDC shall be supplied under this contract including all necessary items like auxiliary switches, relays and changeover switches etc. All circuits provided under this contract whether or not they are subject to the system control requirements at the present time, shall be designed and constructed so that the standard facilities specified can be readily provided as required in the future.

5.4.5 The Contractor shall be responsible for ensuring the correct operation of the protective equipment and shall submit for approval recommended relay settings supported by design calculations for all protective equipment being supplied. The Engineer reserves the right to ask the Contractor to get the design calculations approved by the Manufacturer of the Protection equipment and/or get the confirmation for the suitability of the particular protective relay for the proposed application. In case the proposed Protective relay is not suitable for the proposed application the Contractor shall change to a suitable relay as recommended by the Manufacturer without any cost implications to the Engineer.

5.4.6 Protection facilities have to be arranged as shown in the Trip Matrix provided in the Bid document.

5.5 Multi-Core Cable Diagrams

Diagrams of communication arrangements will be made available to the Contractor who will be required to coordinate the provision of necessary multi-core cabling. This contract includes

the preparation of cabling schematic diagrams, showing the approved routing of cores in the various cables, and detailed cable schedules and connection diagrams for all the cables associated with each item of equipment.

5.6 Test and Earthing Facilities

5.6.1 Each control or relay panels shall be provided with a copper earth bar of not less than 150 sq.mm Cross-section and arranged so that the bars of adjacent panels can be joined together to form a common bus.

5.6.2 The common earthing busbar of control and relay panels shall be connected to the main station earthing system via a copper earthing connection of not less than 150 mm^2.

5.6.3 Software for testing the protection & control devices shall be included in the scope of supply. In addition, for secondary injection testing of the protection & control devices, provision shall be made in the panel for current & voltage injection using standard test set and disconnecting type terminal blocks with facility for short circuiting of current transformer secondary circuit etc. by means of movement of links from their normal operating position, or any other testing arrangement approved by the Engineer.

5.6.4 Panel front mounted Test Terminal Blocks (TTB)/Test Sockets have to be provided for online testing of all Protective relays. Facility of online CT shorting, VT circuit isolation should be available in the TTB. 2 sets of associated Test Plugs should also be supplied for each substation under contract.

5.7 Protection Devices

5.7.1 Simplified arrangements of the main connections and protection for the various items of the substation are shown in Bid Drawing.

5.7.2 Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits. All equipment is to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

5.7.3 Current transformers, where possible, are to be located so as to include the associated circuit breaker within the protected zone and shall be located generally as indicated on the schematic drawings included in this Specification.

5.7.4 Transformer Buchholz, winding temperature, oil temperature, tap changer protective devices and pressure relief devices are to be supplied under this contract, and all necessary interposing relays, tripping relays and cabling associated with these devices shall be supplied and mounted under this contract.

5.8 Relays

5.8.1 General: Relays shall be of approved types complying with IEC 60255 or British Standard 142 and 5992, Parts 1,2 and 3 as appropriate, fully tropicalized, and shall have approved characteristics. Relays designed identical to relays with a minimum of five years proven field experience will only be accepted. Supply record of proposed relays shall be furnished for the last five years. The Engineer will reject any design he considers unsatisfactory or having insufficient field experience. All the protective relays

shall be numerical type only. Numerical relays shall be configured in such a way that at least 2 nos. relays shall be provided for each feeder.

5.8.2 The protection relays, shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases and of the draw out type with rear connections.

5.8.3 Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be affected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

5.8.4 Electrically reset tripping relays shall be provided where necessitated by the system of control, such as for those circuits subject to remote supervisory control.

5.8.5 Relay contacts shall be suitable for making and breaking the maximum currents which they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved auxiliary contacts, relays or auxiliary switches shall be provided. In such cases the number of auxiliary contacts or tripping relays operating in tandem shall be kept to the minimum in order to achieve fast fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

5.8.6 Relays, where appropriate, shall be provided with LED or flag indicators, phase coloured where applicable. LED or Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element.

5.8.7 All Relay settings shall be visible and readable without having to remove the relay front cover. It shall not be possible to amend relay settings with the front cover in place; other than over a serial link.

5.8.8 If a connector for local use is provided this shall be accessible only after removing the front cover. Where a port is provided for permanent connection to a modem or other peripheral equipment, remote access shall be password protected.

5.8.9 Relays which rely for their operation on an external DC supply shall utilise for this purpose the trip supply of the associated circuit breaker trip coil. This supply shall be monitored and an alarm provided in the event of failure.

5.8.10 Any auxiliary supplies needed shall be drawn from the main station batteries and not from separate internal batteries in the protection equipment.

5.8.11 Relays, whether mounted in panels or not, shall be provided with clearly inscribed labels describing their function and designation in addition to the general purpose labels.

5.8.12 Attention is practically drawn to the tropical climate and relay designs should be entirely suitable for duty under full tropical conditions.

5.8.13 To minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energized from the positive pole of the battery.

5.8.14 Relay shall be suitable for operation on 110 V nominal, 121 V float DC systems without the use of voltage dropping resistors or diodes

5.8.15 Numerical protection shall be designed in such a way that in case of a failure of DC auxiliary infeed, the full information needs to be maintained at least 24 hrs. After a recovery of DC auxiliary infeed, the last information and alarms will be displayed and the alarm "failure of DC auxiliary infeed" released. The relay reset shall not erase the relay memory.

5.8.16 The Numerical protection functions shall be in the form of software such that additional or different functions, application specific logic etc. can be readily implemented without changes to the existing hardware. It shall be possible to programme/ parameterize by a portable computer (PC) all the numerical protective relays and the entire relay operating and configuring software and the portable computers and other accessory equipment needed to communicate with the relays shall be provided.

5.8.17 All numerical relays shall be adequately protected against damage from incoming surge and shall meet relevant IEC, BS and ANSI SWC test standards. Relays shall utilize a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation.

5.8.18 In addition, to all equipment and components, the Contractor shall supply documents and calculations to prove the correct functioning of the equipment and he shall ensure and demonstrate that the setting range of relays and the operating limits of all equipment is suitable for the intended applications.

5.8.19 Electromagnetic Compatibility

5.8.20 In certain cases, e.g. distance protection, current differential etc., electronic relays, or devices utilising microprocessors are specified and electromagnetic devices will not be accepted.

5.8.21 Where such devices are required, they and the ancillary circuits connected to them, such as power supplies, current and voltage transformer secondaries, status or tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an EHV substation.

5.8.22 Adequate steps, by means of suitable design, shall be taken to prevent Electromagnetic Interference (EMI) (generated by sources such as circuit breakers, disconnectors, lightning, radio or radar emissions, switching contactors in dc circuits etc.) or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.

5.8.23 All relays offered must therefore have been type tested to meet the current requirements of IEC 60255 with respect to High Frequency disturbance, Fast Transients, Electrostatic Discharge, Radio Frequency Interference testing etc.

5.9 Overhead Line Protection

5.9.1 400kV, 230kV and 132 kV Transmission Line Protection

Protective devices for Main 1 and Main 2 overhead line protection are shown on Bid Drawing. These devices shall comply with the following. For 400KV transmission lines two sets of line differential relays shall be proposed which must be matched with the remote ends if necessary, remote end relays shall be also included in the scope of supply with necessary communication equipment.

5.9.1.1 Main 1 and Main 2 protection of 230 kV & 132KV line shall be of Line differential protection with back-up distance protection for short length or if the remote end already has line differential relay. Line differential protection is optional of Long and Medium length lines. Definition of Long, Medium and Short length line is base on Clause 5.2 of IEEE Std. C37.113™-2015. The Main & Back-up protection of 132

kV line shall be Line differential with full scheme distance protection or Distance protection alone (based on the criteria above) and Directional overcurrent & Earth fault protection respectively. Main 1 and Main 2 both protection of 230 kV line shall be Line differential with full scheme distance protection or Distance protection alone (based on the criteria above). Both Main-1 and Main-2 protections should operate in conjunction with tele-protection channels over optical fibre for tele-protection schemes of distance protection. All relays shall be of numerical type. The philosophy of PSLD & Trip logics will be applied in all aspects.

5.9.1.2 Each set of protection will be energised from separate current transformers and shall have facilities for independently tripping duplicated circuit breaker tripping coils and initiating auto-reclosing, breaker failure protection, inter-tripping, alarms, fault location equipment, disturbance recorders etc. The Contractor shall ensure that the relay contacts used for initiation of auto reclosing shall have the same dwell time as the main tripping contacts to avoid any problems arising from contact racing with the auto reclose relay.

5.9.1.3 Separate elements shall be provided for phase and earth fault measurement. Separate elements shall also be provided for each zone. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of fault and to allow for variation in the path of earth faults on the system.

5.9.1.4 The relay scheme offered shall be suitable for use in the permissive under-reaching, permissive overreaching, direct transfer trip, CB Echo logic, Weak End Infeed Echo logic, blocking and unblocking modes for Distance (21) and Directional Earth Fault (67N) functions. All these options shall be contained and selectable in the standard relay scheme. The relay should be applicable to all neutral ground possibilities and should be suitable for the protection of long, medium or short overhead lines or cables, double circuit lines, heavily loaded lines, lines with weak infeed etc.

5.9.1.5 To provide high speed tripping when a line terminal is open a 'signal echo feature' shall be provided, which is initiated when either the feeder disconnector is open, or when the associated circuit breakers are open.

5.9.1.6 The Zone 1 elements will normally be set to approximately 80 per cent of the line impedance. They shall trip the local line circuit breaker.

5.9.1.7 The Zone 2 elements will be set to overreach the remote substation and in the case of permissive over-reaching mode operate in conjunction with teleprotection signalling channels to form a permissive over-reaching scheme. They shall also act as a back-up time delayed zone which trips the local circuit breaker. In the case of permissive under-reaching mode protection the overreaching Zone 2 unit will be used as the permissive element to permit instantaneous tripping of the local circuit.

5.9.1.8 The Zone 3 elements shall provide a further time delayed back-up zone.

5.9.1.9 Distance protection back-up zones shall also have the facility to trip the remote end circuit breaker(s) via a direct intertripping channel.

5.9.1.10 Partially cross polarized mho or polygonal impedance characteristics relays are preferred for Zones 1 and 2 for 3-phase and 2-phase faults but other characteristics will be considered. Quadrilateral characteristics with adaptive reactance measurement to avoid overreach or underreach for resistive faults with pre fault

load are preferred for earth faults. The relays shall operate for faults in the direction of the protected line only. Under no circumstances shall they operate for reverse faults even when the voltage supplied to the relay falls to zero on all three phases nor shall they operate due to the transient response of the capacitive voltage transformers following reverse close-up faults if the protection zone is selected for forward region. Details of methods used for polarising the relays to deal with faults close to the relaying point shall be provided. Zone 3 shall be capable of being set as either directional or non-directional and shall be capable of being independently off set in both directions.

5.9.1.11 The reach of each zone and reverse element shall be individually adjustable by means of a multi-tap voltage transformer or other approved method. The characteristic angle shall be adjustable between approximately 40 and 80 degrees.

5.9.1.12 Where used in a permissive overreach transfer tripping scheme with weak infeed tripping the zone 3 unit may be set looking in the reverse direction. The reverse looking impedance/directional elements shall detect all reverse faults capable of being detected by the Zone 2 relay at the remote substation. Bidders shall explain how this is achieved.

5.9.2 Single pole tripping and auto-reclosing are being employed and the auto-reclosing scheme requirements are given in Section 5.11. The distance protection shall be suitable for such a scheme and the Contractor shall substantiate by calculation or other means that phase selective tripping will be achieved under the system conditions anticipated in the daily operation. The Contractor may request whatever information he requires for carrying out the necessary calculations.

5.9.2.1 Auto reclosing shall be capable of being blocked for

i. any multi-phase fault
ii. any Zone 2 or Zone 3 time delayed trip
iii. Tele-protection channel out of service
iv. DEF back up time delayed trip without teleprotection aided scheme.
v. Switch on to fault.

5.9.3 The necessary circuitry shall be incorporated to inhibit the Zone 1 and Zone 2 phase fault elements when necessary during single phase to earth faults and during the single phase auto-reclose dead time. These features shall be selectable by links or switches. Provision shall also be made to ensure that the earth fault elements reset during the single phase dead time.

5.9.4 The protection sensitivity shall be shown to be adequate for the minimum fault level conditions. These will be advised to the Contractor at a later stage

5.9.5 Where fault resistance may be significant, the Contractor shall illustrate that the distance protection can cover such values taking fault current distribution and load conditions into account.

5.9.6 The operating time of each distance protection zone shall be substantially independent of fault current magnitude. The operating times shall be stated in the Schedule of Particulars and, in addition, curves shall be provided showing the effect of line and source impedance, fault position and operating current.

5.9.7 Under no circumstances shall any line protection operate because of normal system switching including de-energisation of the line.

5.9.8 A feature shall be incorporated to ensure instantaneous tripping in the event that the circuit breaker is closed onto a fault on a previously de-energised line.

5.9.9 Distance protection back-up Zone 2 and Zone 3 time delay setting ranges shall be 0.2 to 1.0 seconds and 0.5 to 3.0 seconds respectively.

5.9.10 A carrier receives signal extension timer with a delay on reset of 100 msec. shall be provided to ensure that relays at both ends of a parallel feeder circuit have sufficient time to trip for faults occurring in the end zones of the protected line.

5.9.11 A monitoring system shall be provided to supervise the voltage transformer supply to each set of distance protection. In the event of loss of one, two or three phases, the monitoring system shall inhibit relay operation and initiate an alarm. The VT supervision unit associated with the distance relay shall also inhibit the DEF protection in the event of VT fuse failure.

5.9.12 All relays shall incorporate indicators to show the relay tripped, zone indication and the phase or phases faulted. Indication must not be lost in the event of a supply failure

5.9.13 Directional earth fault protection operating in a permissive overreach scheme shall be provided to cater for high resistance faults which cannot be detected by the distance protection. The same teleprotection signalling channel shall be used for the directional earth fault scheme and the distance protection scheme. An echo feature shall be included with the DEF Scheme and shall be subject to approval by the Engineer.

5.9.14 The directional relays shall be dual polarised i.e. polarised with zero sequence voltage and current. The relay sensitivity shall be adjustable between approximately 5 and 10% of rated current. A relay characteristic angle of 60 degrees is preferred but alternative angles will be considered. It is appreciated that because the 230 kV system zero sequence source is an auto transformer with a delta tertiary winding, that current polarising of a dual polarised relay is unreliable without careful analysis. The Contractor shall be responsible for determining whether such a current signal can be taken from the auto transformer neutral and safely used for polarising the relay within three months of being advised of all transformer impedance parameters.

5.9.15 The directional earth fault protection shall initiate three pole tripping. It must therefore include a short time delay to permit single pole tripping by the distance protection. Initiation of three pole reclosing following operation of a DEF aided trip shall be selectable by means of a switch.

5.9.16 Directional earth fault relays shall incorporate a back-up stage in addition to the aided tripping unit. The time delay range shall be 0.2 to 5.0 seconds or inverse time delayed with a characteristic to IEC 60255.

5.9.17 Neither the distance protection scheme nor the directional earth fault scheme shall mal-operate due to fault current reversal during sequential clearance of a fault on the parallel circuit.

5.9.18 The effect of zero sequence mutual coupling between the double circuit lines on the protection shall be described, together with any measures considered necessary to overcome this effect.

5.9.19 The distance protection time delayed back-up Zones 2 and 3 and the directional earth fault back-up stage shall inter-trip the remote station circuit breakers over direct inter tripping channels.

5.9.20 Auto reclosing shall not be initiated on receipt of direct inter-tripping signal. Direct inter-tripping shall also be initiated in the event of a 3 phase fault in any zone, or following a switch on to fault trip.

5.9.21 Distance relays shall be supplemented by power swing blocking relays. Power swing blocking relays shall be compatible with their appropriate distance relays, and for distance relays having offset mho zone 3 characteristics or starters shall comprise an offset mho characteristic which encompasses and is concentric with the distance relay

impedance starter or zone 3 characteristic. Similarly, where it is possible to shape the zone 3 or starter characteristic the power swing blocking relay characteristic shall also be capable of similar shaping. Where zone 3 is set reverse looking the power swing blocking characteristic shall be set such that it encompasses the forward-looking zone 2 characteristic.

5.9.22 Facilities shall be provided to block zones 1, 2 and 3 of the distance relay from the power swing blocking logic as required.

5.9.23 Blocking logic shall be derived by determining the time taken for the apparent impedance of the power swing locus to pass from the characteristic of the power swing relay to the appropriate distance relay characteristic. Blocking shall not take place until the apparent impedance has passed through the two power swing characteristics and the set time delay has expired.

5.9.24 The associated time delay relay shall have a setting range of 50-250 ms.

5.9.25 Relays shall be of numerical design. Electromechanical relays will not be accepted. The Numerical relays shall be design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self-supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Distance to fault indication, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this man machine communication (MMC) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection. A separate communication port shall be provided so that the distance relays can in future communicate with the Station monitoring system as well as easily be integrated into Station Control Systems. A PC with a man machine communication (MMC) software for setting of the relay shall be included in the scope of supply.

5.9.26 Reset times shall be low to ensure the associated distance relay reverts to its normal role as soon as possible following a power swing.

5.9.27 Power swing blocking shall be inhibited during the single pole dead time of an auto reclose cycle so that if a power swing develops during this period the distance protection can give an immediate three phase trip. The Bidder shall advise whether it is possible to extend the inhibition of the power swing blocking to cover a period immediately following auto reclosing so that if a power swing develops on reclosing onto a permanent fault a 3-phase trip would be permitted. The Bidder shall also advise whether power swing blocking can be inhibited if an earth fault occurs during a power swing.

5.9.28 If the associated VT supplies are lost due to VT fuse failure the power swing blocking relay shall not operate.

5.9.29 Where protection is supplied from multi-ratio current transformers, the lowest ratio will be used for the initial system configuration, when fault levels are low. The working ratio will be increased when the system expands and the fault levels and load transfers increase.

5.10 Busbar Protection

5.10.1 The busbar protection for 400kV (1 & 1/2 Breaker and Double Busbar scheme), 230kV & 132kV shall be low impedance type numerical relay capable of detecting all types of phase and earth faults under all system generation conditions. Busbar protection system should be distributed in principle. The protection shall be extensible to cover

the final substation arrangements and Bidders shall state what extra material is required.

5.10.2 Each busbar having voltage levels of 230KV and above shall be protected with 2 (two) sets of Main and Redundant busbar protection system. Two sets of busbar protection should be from two different manufacturers.

5.10.3 The busbar protection shall meet the fault clearance time of 80ms for 400kV under all conditions and have the following features:

5.10.3.1 In case of 400kV busbar protection, two independent measurement, protection & tripping criteria shall be applied.

5.10.3.2 One based on stabilized current differential algorithm and the other on directional current comparison and shall be capable of detecting three phase, phase-phase and phase to earth faults, under all system generation plant conditions.

5.10.3.3 logics and close blocks for Busbar protection operation will be implemented as shown in PSLD & Trip logic and associated trip matrix.

5.10.3.4 The operating time of the measuring relays shall not exceed 30msecs at five times the relay current setting.

5.10.3.5 The busbar protection should be capable of feeding from different ratio of current transformers in different feeders. The working ratio will be selected on the basis of maximum load transfer in the same manner as the line current transformer ratios.

5.10.3.6 The rated stability limit of the protection shall not be less than the switchgear short circuit rating.

5.10.3.7 Stability against all external faults must be confirmed even in case of severe CT saturation.

5.10.3.8 Automatic and continuous supervision of current transformer circuits shall be provided to give an alarm when the out-of-balance current reaches an undesirable value. Operation of differential current supervision element should take the defective protection zone out-of-service.

5.10.3.9 The Contract shall include for all necessary current transformers, relay panels, marshalling boxes, isolating and shorting links, etc. 5 (five) nos selector switches have to be provided for enabling and disabling BBP (Busbar Protection), BFP (Breaker Failure Protection), EFP (End Fault Protection), Output contacts and All functions.

5.10.3.10 Suitable voltage limiting devices shall be provided as necessary, including across the unused part of the CT secondary when tapings are employed.

5.10.3.11 Full details of the scheme offered, together with performance figures for stability and sensitivity shall be provided.

5.10.3.12 The numerical busbar protection shall be multi processor in structure, with extensive self-supervision, 16 bit analogue to digital converters, together with appropriate algorithms to provide phase segregated measuring principles and multi criteria evaluations before initialisation of trip commands. The bay units shall be fixed as close to the CTs as possible reducing the copper wiring to a bare minimum and thereby also reducing the CT burden and CT dimension.

5.10.3.13 If the intercommunication between the bay unit and central unit by fibre optic cables, the required fibre optic cable and all necessary items shall be supplied, connected and commissioned by the Bidder. Fibre optic cables connected between

panels have to be appropriately armourd, sealed and protected from external disturbances.

5.10.3.14 Front mounted HMI should be provided with Central Unit and each Bay Unit of busbar protection system having facility of accessing all relevant measurements, alarms, tripping information and switching device information without connecting external computers.

5.10.3.15 Complete configuration including software and hardware capabilities should be available in BBP system for accommodating existing feeders as well as future feeders. No further engineering would be required during extension of future feeders, only installing new Bay Units should be sufficient.

5.10.4 Extension of existing busbar protection: The scope of work under this contract is to extend the existing busbar protection for new bays with the same equipment.

5.10.5 Conditions of Acceptance of Busbar Protection Systems Submitted on the Basis of Calculated Performance

The Contractor shall prepare for approval calculated performance data for differential busbar protection systems in lieu of heavy current tests, subject to the following:

i) The rated stability limit shall be no less than the three-phase symmetrical breaking capacity of the associated switchgear.

ii) ~~The overall fault setting for any type of fault shall be between 10% and 30% of the minimum fault current available. The minimum fault current available for a busbar fault will be advised later.~~

iii) Current transformer knee point voltages shall not be less than twice the relay circuit setting voltage.

iv) The maximum peak voltage across current transformer secondary wiring shall not exceed 3 kV under maximum internal fault conditions.

v) Associated current transformers shall be Class X or 5P, low reactance type. Split core type current transformers will not be accepted.

vi) The Contractor shall submit for the Engineers approval a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burdens between current transformers and relays, details of the relay circuits and performance calculations.

5.11 Circuit Breaker Failure Protection

5.11.1 Breaker failure protection shall be fitted to all 400kV, 230 kV and 132 kV circuit breakers of the substation. Each CB having voltage level of 230KV and above will be equipped with 2 (two) nos main and redundant Breaker Failure Protection. The breaker failure protection on a circuit breaker shall be initiated by all the other protection devices which normally initiate tripping of that breaker including the receipt of a direct inter-tripping signal from a remote line end. In the event of the circuit breaker failing to open within a pre-selected time, the breaker failure protection shall issue a re-trip to the same Circuit Breaker through an alternative path of the initially issued trip signal. If the Circuit Breaker fails to open even after receiving the re-trip signal, the BFP will initiate tripping to ~~all adjacent~~ circuit breakers of all connected sources. It shall also

incorporate provision for initiating tripping of any remote infeeds, via direct inter-tripping channels over optical fibre communication link or power line carrier circuits.

5.11.2 On the other hand, BFP remote tripping from the remote infeeding end will be received by the local end relays to issue tripping to local end CBs.

5.11.3 In the case of 400kV, 230 kV and 132 kV circuit breaker failure protection, the position of each circuit breaker shall be monitored by a current check relays fed from the protection current transformers as shown on the drawings. The relays shall have an operating time of approximately 10 msec. and a consistent reset time of less than 15 msec. The relays shall be capable of remaining in the operated position continuously and of carrying twice the circuit rated current continuously.

5.11.4 The operating time from initiation to back-up tripping output shall be selected by means of duplicated timers with a setting range of 50-500 msec.

5.11.5 The timers shall be of a modern design to minimise overtravel. With the approval of the Engineer the busbar protection trip circuits may be employed for circuit breaker fail back-up tripping.

5.11.6 In the event that a circuit breaker is unable to trip due to low gas pressure, low hydraulic oil pressure etc. the associated alarm shall be arranged to by-pass the breaker fail time delay. The breaker fail relay/scheme shall be designed to accept this input.

5.11.7 Operation of the breaker fail protection shall block manual and automatic reclosure of the associated circuit breaker. Breaker failure protections inbuilt in distance / transformer relays will not be accepted.

5.11.8 Breaker Failure Protection will be implemented as a built-in function of Busbar Protection system for Double Busbar bus arrangement. Same will be applicable for Bus side Circuit Breakers of 1 and half CB bus arrangement. Stand-alone Breaker Failure Protection relay can be provided for Tie CB of 1 and half CB bus arrangement depending on manufacturer's practice.

5.12 End Fault Protection

5.12.1 Blind zone between Circuit Breaker and Current Transformer needs to be protected with End Fault Protection where overlapping protection zones are not formed due to CT location.

5.12.2 End Fault Protection will be implemented as a built-in feature of busbar protection system.

5.12.3 Tripping will be issued to remote infeeding end either through direct inter-tripping (in case of transformer) or through Tele-protection channel (in case of OHL) with selectable time delay if EFP is detected.

5.13 Auto-Reclosing Scheme

5.13.1 Three pole and/or single pole, single shot repetitive auto-reclosing equipment, shall be provided for the overhead line circuit breakers.

5.13.2 Reclosure shall be initiated following tripping by either main protection operating in Zone 1 or in conjunction with a tele protection receive signal or DEF with teleprotection aided scheme. Selection facilities shall also be provided to enable or block three pole delayed auto-reclosing following operation of the directional earth fault protection aided trip output. Re-closure shall not be initiated in the event of a three phase fault, nor any type of fault in the second or third back-up zones, nor when a direct inter-tripping signal is received, nor when the circuit breaker is closed onto a fault on a previously de-

energised line, nor when the DEF back-up protection operates nor if the carrier channel is out of service nor O/C & E/F protection operated nor voltage protection operated.

5.13.3 The following modes of operation shall be selectable by means of a switch or switches or programmable.

(a) Single pole, high speed, auto-reclose: Auto-reclosure shall only be initiated in the event of a single phase to earth fault. All other types of faults shall result in three phase tripping without auto-reclosing.

(b) Three pole delayed reclosing: Delaying reclosing shall only be initiated in the event of a single phase or two-phase fault. Three phase faults shall result in tripping without auto-reclosing.

(c) Single pole, high speed and/or three phases delayed, auto-reclosing as appropriate. Single pole, high speed auto-reclosing shall be initiated only in the event of a single phase-earth fault and delayed reclosing initiated in the event of a two-phase fault. Three phase tripping without re-closing shall take place for three phase faults.

5.13.4 If a second earth fault occurs during the single pole auto-reclose dead time, and the selector switch is in the single and/or three pole reclosing mode three phase tripping with subsequent delayed three pole auto-reclose shall take place. If the auto-reclose selector switch is in the single pole reclose mode, three phase tripping with lockout should follow. Any auxiliary relays required to meet this logic shall be deemed to be included.

5.13.5 The high speed and delayed reclosing dead times have to be coordinated with the equipment being provided at the remote substation. Tentative ranges are, as follows:

- High speed single pole reclose dead time: 0.3 to 3 seconds.
- Delayed three poles reclose dead time: 3 to 30 seconds.

Bidders shall state available ranges.

5.13.6 The reclaim time i.e. the time period following the automatic reclosing of the circuit breaker, during which any further fault results in three phase tripping and lockout, shall be chosen to match the duty cycle of the circuit breakers, assuming the shortest available dead time is chosen. The reclaim time shall, however, not be less than five seconds, and the reclaim timer range shall extend to 180 seconds. (The reclaim time commences at the instant the reclose command is given to the circuit breaker and, therefore, includes the circuit breaker closing time).

5.13.7 The closing command shall be limited to two seconds, after which time the reclosing equipment shall be automatically reset without resetting the reclaim timer. The reclosing equipment shall also reset if dead line check or synchronism check conditions are not satisfied within a predetermined time of the check relays being energised.

5.13.8 A counter shall be provided to record the number of reclosures and lockout after a pre-selected number of reclosures has been reached.

5.13.9 The rated duty cycle of the circuit breaker as defined in IEC 60056 (and subsequent amendments) states that following an initial trip and auto reclosure a further reclosure is not permitted for a further 3 mins.

5.13.10 Auto-reclose functions have to be provided in Main-1 and Main-2 relays for voltage levels of 230kV and above. Main-1 line protection relay has to be selected as master for auto-reclose. A/R function of Main-2 relay will be active in case of unhealthiness of Main-1 relay for avoiding duplicated command. In case of 1 and half CB bus arrangement, A/R will be issued to Bus side CB initially. A/R reclose of Tie CB will be issued after successful reclosing of Bus side CB. Alternatively, A/R will be issued to Tie CB initially if the Bus side CB remains open beforehand.

Auto-reclose function will be activated in Main relay only for 145kV.

5.13.11 Reclosing schemes shall include voltage monitoring and check synchronising relays as appropriate.

5.13.12 Dead line check relays shall monitor the condition of the line and busbar and permit three pole reclosing only when the line is de-energised and the busbar is energised. The line is considered to be de-energised when the voltage is less than twenty percent of rated voltage, and the busbar is considered to be energised when the voltage is greater than eighty percent of rated voltage.

(A signal shall be provided from the dead line check relays for interlocking of the line earth switches to prevent the switches being closed onto a live line).

5.13.13 When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall monitor the magnitudes of the two voltages across the open circuit breaker, and the phase angle and slip frequency between these voltages. Closing shall only be permitted when these are within prescribed limits.

5.13.14 Check synchronising relays shall comply with the requirements of Clause 5.24. 1. The same relays may be used as for manual closing.

5.14 Overcurrent and Earth Fault Protection

5.14.1 The overcurrent and earth fault relays shall be fully Numerical and have multi characteristics (inverse, very inverse, extremely inverse) to IEC 60255. Over-current and Earth-fault protections will be implemented as back-up protection of the main feeder protections for line and transformer feeders. The functions will act as main protection for Bus Coupler feeders.

5.14.2 In the case of underground line circuits relays should have a reset ratio greater than 95% to enable settings to be made which are close to the circuit emergency rating. The relay contacts must close at a current equivalent to 110% of the setting and relay overshoot must not exceed 50 msec.

5.14.3 Over-current and earth fault relays shall trip via the CB duplicate trip coils.

5.14.4 Relays shall be thermally rated such that the operating time of the relay at the highest practical current levels on any combination of current and time multiplier settings shall not exceed the thermal withstand time of the relay. The Contractor shall provide copies of type test reports to show that this requirement has been met.

5.14.5 Directional back up over-current and earth fault relays shall be provided for underground Cable, Line and Transformer feeders and the directional elements shall be voltage polarised.

5.14.6 Directional units for directional overcurrent protection shall be quadrature connected with a relay characteristic angle setting of 30° or 45° current leading voltage.

5.14.7 Directional units for directional earth fault back up protection shall employ residual voltage quantities and the relay characteristic angle be variable 0°, 45° and 60°, current lag.

5.14.8 The nominal operating boundary shall be ±90° from the relay characteristic angle and the operating time of the directional unit shall not exceed 20 ms at the relay characteristic angle.

5.14.9 The relay shall be capable of operating correctly when both the operating current and polarising voltage quantities are 1% of rated values at an angle equal to the relay characteristic angle.

5.14.10 The residual polarising voltage for earth faults may reach 190.5 volts and therefore it should withstand this value continuously. The continuous withstand current should be no less than twice rated current.

5.15 Coupling Bay Protection

5.15.1 The Coupler bay shall be provided with overcurrent instantaneous trip relay protection (50/50N) and overcurrent time delay relay protection (51, 51N). Relays shall comply with the requirements of clause 5.14.

5.15.2 All trip-signal of OHL and transformer feeder protection shall be transferred to the coupling breaker in case the feeder breaker is bypassed and the feeder is protected by the coupling-bay circuit breaker. This shall be provided by auxiliary relay, not by auxiliary contacts of the circuit breaker by-pass isolator.

5.16 Transformer Protection

5.16.1 Biased Differential Protection

5.16.1.1 The transformer differential protection shall be fully numerical design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self-supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Trip indications, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Human Machine Interface (HMI) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection.

5.16.1.2 Overall differential protection shall be of the biased differential type and capable of detecting phase and earth faults.

5.16.1.3 Separate facilities shall be provided to enable bias and operating settings to be adjusted. The minimum operating setting shall not be greater than 20 per cent of the rated full load current of the transformer.

5.16.1.4 The protection shall be designed to ensure stability on any transformer tap position under maximum through fault conditions with maximum d.c. offset even in case of severe CT saturation. An infinite source is to be assumed and the through fault current calculated using the transformer impedance only.

5.16.1.5 Correction for matching transformer vector groups and main CT ratio's for Transformer Differential protection shall be performed within the relay without the use of external interposing-transformer.

5.16.1.6 The relay characteristics should include unrestrained tripping without checking any restraining quantities or harmonics.

5.16.1.7 The relays shall have magnetising inrush current restraint of the second harmonic or other approved means. All necessary interposing current transformers shall be provided under the contract.

5.16.2 Restricted Earth Fault Protection

5.16.2.1 Where specified, or shown on drawings, transformer windings and connections shall be protected by restricted earth fault protection2 (two) separate Restricted

Earth Fault (REF) Protections have to be established for 3 (three) winding Transformers operating in voltage level 230kV or above. 1 (one) will be low impedance type having restraining characteristics and stability against heavy through fault even in case of severe CT saturation. Low Impedance type REF protection can be embedded in Main-1 Transformer differential relay.

5.16.2.2 The 2nd REF protection will be of high impedance type with necessary protection against over voltages. For reliability reasons the restricted earth fault relay shall be separate from the transformer differential relay.

5.16.2.3 2 (two) winding Transformers and transformers operating in 132kV may have only 1 (one) REF with low impedance type and embedded in Main-1 transformer differential relay having operating characteristics described above.

5.16.2.4 33kV winding of Earthing transformer (if any) will also be protected with low impedance type REF protection.

5.16.2.5 Relays shall have maximum sensitivity and minimum operating times consistent with stability for faults outside the protected zone and on magnetising inrush surges.

5.16.2.6 The rated stability limit shall not be less than the maximum current available for an external fault. This shall be taken as 16 times the rated current of the protected winding of the power transformer, or any other value agreed by the Engineer.

5.16.2.7 For the purpose of calculations it shall be assumed that any neutral earthing impedance is short circuited.

5.16.2.8 The Contractor shall prepare for approval calculated performance for instantaneous high impedance restricted earth fault protection in lieu of heavy current tests, except:

i) The rated stability limit shall be as specified above.

ii) The fault setting shall be as specified below.

(a) When the transformer winding is connected to a solidly earthed power system, the fault setting shall be between 10% and 60% of the rated current of the winding. When the transformer winding has more than one rating, the setting shall be based on the lower rating.

(b) When the protected transformer is not connected to a solidly earthed power system the fault setting shall be between 10% and 25% of the minimum current available for an earth fault at the transformer terminals.

5.16.3 Transformer Back-up Over-current Protection

Three-pole inverse time back up overcurrent and earth fault protection shall be provided as shown on the drawings. This shall comply generally with Clause 5.14 but in addition the overcurrent elements shall also be a two stage device. Stage 1 will comprise the inverse time unit and stage 2 will comprise an additional definite time unit with a setting range of 50 msec. - 5 secs.

Over-current and earth-fault elements should have selectable operating characteristics as shown in PSLD & Trip logic.

5.16.4 Gas Pressure (Buchholz) Protection

5.16.4.1 Power transformers and earthing transformers shall be fitted with Buchholz devices under this contract. The Buchholz device will be of the two element type giving operation under gassing and under surge conditions.

5.16.4.2 All necessary flag indication, tripping relays and alarm relays associated with this protection shall be provided, mounted and connected under this contract.

5.16.5 Oil and/or Winding Temperature

5.16.5.1 Transformers will be provided with oil and/or winding temperature protection under this contract. These will be of the two stage type with adjustable settings giving alarm and trip facilities.

5.16.5.2 All necessary flag indication, tripping relays and alarm relays associated with this protection shall be supplied and connected under this contract.

5.16.6 Low Oil Level and Pressure Relief Devices

5.16.6.1 Transformers shall be provided with low oil level with contacts for the purpose of providing remote alarm. Transformers shall also be provided with a pressure relief device with contacts for purposes of remote alarm and trip function.

5.16.6.2 The alarm relays associated with these devices shall be supplied and connected under this contract.

5.16.7 Tap Changer Oil Surge

5.16.7.1 Transformers will be provided with an oil surge or pressure operated device having contacts for purposes of remote alarm and trip.

5.16.7.2 A relay associated with this device shall be supplied and connected under this contract.

5.16.7.3 All necessary flag indication, tripping and alarm relays associated with tap change oil surge shall be provided.

5.16.8 Transformer Mechanical Protection arrangements

All mechanical protection of Transformer will be established either through Main-1 and Main-2 protection relays and through Lock-out type tripping relays with necessary flag and indication. The protections which are established with Main-1 and Main-2 relays, tripping and alarm signals from all devices have to be terminated to both relays for assuring redundancy.

5.16.9 Tripping Relays

5.16.9.1 All tripping relays, where specified shall be of the heavy duty type suitable for panel mounting. The trip relays of the offered numerical protections shall be directly capable of tripping the breaker coils. It shall not be required to add additional trip relays

5.16.9.2 Trip relay contacts shall be suitably rated to satisfactorily perform their required duty and relay operating time shall not exceed 5 ms. from initiation of trip relay operating coil to contact close.

5.16.9.3 Where specified latching type relays shall have hand or electrically reset contacts and hand reset flag indicators. Resetting of the flag indicator and the contacts shall be possible without having to open the relay case.

5.16.9.4 Tripping relays shall operate when the supply voltage is reduced to not higher than 30% of nominal battery voltage. It shall not operate for wiring leakage currents and discharge of wiring capacitance

5.16.9.5 400kV, 230 kV and 132 kV circuit breakers are equipped with two trip coils. One tripping relay shall initiate tripping via one trip coil and the other tripping relay via the second trip coil.

5.17 DC Auxiliary Voltage Operating Range

DC operated relays, coils, elements, etc. will be operated from a 110V rated dc. battery, which under float charging conditions operates at about 125V. DC operated relays coils elements etc. shall be suitable for operation over a voltage range of 66V to 143V. i-e. 110 - 40% + 20%.

DC automatic changeover scheme has to be provided in each control & protection panel. Main-1 relays, Trip Circuit-1, Lock-out relay-1 should be connected to DC-1 and Main-2 relays, Trip Circuit-2, Lock-out relay-2 should be connected to DC-2 in normal condition. In case of failure of one DC system, the other system will automatically take care of the devices under the failed one.
Similarly for Control Panel, BCU will be supplied from DC-1 and Mimic/Emergency Control will be supplied from DC-2 in normal condition. DC changeover will be implemented as stated above.
DC supply of each panel will be taken directly from DCDB through separated MCB. DC looping among panels will not be accepted.

5.18 Tele-protection Signalling

Details of protection initiation and various permissive and direct inter-tripping signals are as specified in Section-14, of Vol. 2 of 3.

5.19 Digital Fault and Disturbance Recorder (DFDR)

5.19.1 The DFDR shall be delivered only for all new 400/230/33kV, 400/230/132kV, 400/132 kV and strategically important 132/33kV substations.

5.19.2 For the purpose of standardization, the DFDR to be supplied under this project shall be from Qualitrol (Belgium/UK), SIEMENS (Germany) , SEL (USA) or equivalent.

5.19.3 Installation, testing & commissioning of the DFDR shall be done by the DFDR Engineer(s) of the DFDR Manufacturer(s).

5.19.4 Since some of the above mentioned make, viz., Qualitrol (Belgium/UK), SIEMENS (Germany),SEL (USA) DFDR is already existed in PGCB's System and their performance is proven, only Manufacturer's Authorization letter among the Qualification Criteria of sub-clause 2.5 of Section 3 of volume 1 of 3 of the Bidding Document is required to be submitted with the bid of the bidders who choose to propose DFDR from these proven manufacturers. Acceptance of any other DFDR with similar characteristics shall have to fulfill the Qualification Criteria of sub-clause 2.5 of Section 3 of volume 1 of 3 of the Bidding Document.

5.19.5 The DFDR shall have the following features:

5.19.5.1 The equipment shall be an independent stand-alone system to monitor analogue and digital signals from all 400kV, 230 kV & 132 kV feeders, including transformer and bus coupler bays that require to be monitored.

5.19.5.2 The Manufacturer shall prove the system's reliability and good site performances by providing substantial evidence of the systems already installed and commissioned for at least a duration of 5 years, accompanied by the customer's recommendations and type test reports from internationally acclaimed laboratories.

5.19.5.3 The DFDR system shall be modular in design for easy expansion, upgrade and maintenance.

5.19.5.4 The acquisition system or its storage unit shall not be based on a PC platform.

5.19.5.5 The independent DFDR system shall be equipped with a minimum of sufficient numbers of signals per bay as tabled below and shall be suitable for AC/DC measurement without any hardware changes.

Voltage Level	Input Type	Type of Feeder/System	Number of Inputs per Feeder/System
400kV	Analog	Line feeder	4 currents + 4 voltages = 8 in total
		Transformer feeder (400/230/33kV or 400/132/33kV)	4 currents + 4 voltages = 8 in total
		Bus Coupler feeder (for Double Busbar)	4 currents
		Busbar Protection System	4 voltages
		DC System	2 voltage
	Digital	Line feeder	36
		Transformer feeder (400/230/33kV or 400/132/33kV)	30
		Reactor feeder	16
		Tie section (for 1 and half bus arrangement)	7
		Bus Coupler feeder (for Double Busbar)	12
		Busbar Protection System	16
230kV	Analog	Line feeder	4 currents + 4 voltages = 8 in total
		Transformer feeder (230/132/33kV)	4 currents + 4 voltages = 8 in total
		Transformer incoming feeder (400/230/33kV or 400/132/33kV)	4 currents + 4 voltages = 8 in total
		Bus Coupler feeder (for Double Busbar)	4 currents
		Busbar Protection System	4 voltages
		DC System	2 voltage
	Digital	Line feeder	34
		Transformer feeder (230/132/33kV)	28
		Transformer incoming feeder (400/230/33kV or 400/132/33kV)	8
		Tie section (for 1 and half bus arrangement)	5
		Bus Coupler feeder (for Double Busbar)	12
		Busbar Protection System	8
132kV	Analog	Line feeder	4 currents + 4 voltages = 8 in total
		Transformer feeder (132/33kV)	4 currents + 4 voltages = 8 in total
		Transformer incoming feeder (230/132/33kV)	4 currents + 4 voltages = 8 in total
		Bus Coupler feeder	4 currents
		Busbar Protection System	4 voltages
		DC System	2 voltage
	Digital	Line feeder	26
		Transformer feeder (132/33kV)	24
		Transformer incoming feeder (230/132/33kV)	8

Voltage Level	Input Type	Type of Feeder/System	Number of Inputs per Feeder/System
400kV	Analog	Line feeder	4 currents + 4 voltages = 8 in total
		Transformer feeder (400/230/33kV or 400/132/33kV)	4 currents + 4 voltages = 8 in total
		Bus Coupler feeder (for Double Busbar)	4 currents
		Busbar Protection System	4 voltages
		DC System	2 voltage
	Digital	Line feeder	36
		Transformer feeder (400/230/33kV or 400/132/33kV)	30
		Reactor feeder	16
		Tie section (for 1 and half bus arrangement)	7
		Bus Coupler feeder (for Double Busbar)	12
		Busbar Protection System	16
		Bus Coupler feeder	8
		Busbar Protection System	8

5.19.5.6 The system shall be equipped to monitor, detect and record simultaneously fast transient faults (short-term) and slow phenomena disturbances (long-term) like power swing, frequency variation, voltage drop, etc., covering all the required feeders.

5.19.5.7 DFDR must comply all requirements stated in attached GTP of DFDR.

5.19.5.8 The graphical data should be recorded for all feeders simultaneously (snap shot image). The recording should contain the data prior to the event and after the event, including the dynamic length of the event / fault without any alterations.

5.19.5.9 The system should possess a library of sensors (triggering criteria), which should be selected by the user and shall be able to detect and record various type of incidents. The system shall be able to detect incidents by the selected starting criteria and should be able to produce a record.

5.19.5.10 The recordings shall contain the graphical data of physical inputs (voltage, currents, digitals) and virtual inputs (e.g. frequency, dp/dt, dq/dt (3 phases / single phase), RMS values etc.).

5.19.5.11 The DFDR shall be able to communicate with local and / or remote master stations, using master communication and analysis software. This software should permit the user either locally or remotely to download the recorded data, to ascertain the system's operational status, to change parameters, etc.

5.19.5.12 Master communication should be able to communicate via RS 232 (direct connection), through modem (dial-up telephone line) and LAN (Ethernet (TCP / IP) - IEEE 802.3) networking.

5.19.5.13 The DFR shall perform the following functions:

- fault location (including impedances and report),
- graphical display of data,

- phase measurement & display,
- transient fault recording,
- dynamic swing recording,
- harmonics' measurement & display,
- integrated SER function,
- calculated channels etc.

5.19.5.14 The system shall be able to calibrate at site, and the required menu-driven software and other required accessories shall be supplied along with a notebook computer, colour printer etc.

5.19.5.15 The system shall be equipped for time synchronization by the external GPS clock receiver for real time synchronizing (including antenna). GPS shall be capable of synchronizing PMU .

5.19.5.16 Local printing facility shall be provided with the system.

5.19.5.17 The master station (a latest version of PC) and the relevant software shall be supplied with the equipment for analysis and communication.

5.19.5.18 Power quality monitoring shall be made available for at least 4 feeders. Continuous monitoring (periodical recording) shall be available for all feeders.

5.19.5.19 If more than one Central Processing Unit is used for DFDR, configuration has to be done in such a way that records from all feeders will be stored in case of triggering any signal.

5.19.5.20 In addition to above, manufacturer shall provide warranty for its product at least for 5 years.

5.19.5.21 DFDR must be integrated with central master station located in Dhaka. Necessary hardware, software and license must be supplied for integrating the DFDR central Master station.

5.19.5.22 Phasor measuring unit (PMU) functionality shall be provided, which can be an integrated feature of DFDR or standalone IED.

5.19.5.23 Separate panel must be supplied for DFDR IPC or working station.

5.19.5.24 The complete DFDR system (including IED & Panel) for all voltage levels (400kV, 230kV & 132kV) shall be supplied from a single eligible manufacturer which shall be selected from any of the enlisted manufacturers as stipulated in the clause 5.19.2.

5.19.6 Extension of the existing DFDR: The scope of work under this contract is to extend the existing DFDR system for new bays. All necessary input and output (both digital & analogue) shall be provided as per the existing bays.

5.20 Travelling Wave Fault Locator (TWFL)

5.20.1 All line of 400kV voltage level or above shall be equipped with Travelling Wave Fault Locator (TWFL) for determining accurate fault location. The TWFL shall be suitable both for Single ended & Double ended application. For achieving double ended application necessary equipment & panel for the remote end Substation must be supplied. For LILO transmission lines TWFL shall be matched with remote end substation.

5.21 Tripping Relays

All tripping relays, where specified, shall be of high-speed (preferably 5 ms), high-burden, heavy-duty (larger than 150W) type and shall be suitable for panel mounting. Relays shall comply with the requirements of attached GTP. The relay used shall be of USA/Europe/Japan origin or other eligible countries with equivalent quality.

5.22 Protection Settings

5.22.1 Relay settings with calculation for all unit-type protective schemes shall be submitted to the Engineer and Employer prior to commissioning of any plant for approval. Settings shall also be provided for those relays and other equipment provided under this section of the contract which do not require an intimate knowledge of existing relay settings e.g. circuit breaker fail relays. Detailed calculations shall be provided supporting all recommended settings.

5.22.2 Computer Aided Setting Calculation shall be performed by the contractor and submit to the Engineer and Employer for approval. Software used for simulation shall be acceptable to & used to by PGCB. Hence, Contractor is requested to consider this software for simulation. Other software is also acceptable with the consent & approval of Employer. Contractor shall submit soft copy files of software for review & approval from Employer. A Power point demonstration is to be foreseen by the contractor for final approval.

5.22.3 Any additional information needed by Contractors should be requested.

5.23 Substation Automation System

5.23.1 Scope of Supply

5.23.1.1 This specification covers the design, manufacture, inspection, testing at the Manufacturer's works, erection and commissioning of a substation automation system, as shown in drawing of this technical specifications& described in the following sections, to control and operate the 400kV, 230 kV &132 kV grid substation.

5.23.1.2 This describes the facilities required to provide the control of plant and system within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

5.23.1.3 The substation automation system (SAS) shall comprise full station and bay protection as well as control, monitoring and communication functions; it shall provide all functions required for the safe and reliable operation based on IEC 61850 standards. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package, and shall perform the necessary system control and data acquisition functions. It shall include two (2) communication gateways to NLDC, inter-bay bus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing.

5.23.1.4 The communication gateway shall secure control from and information flow to remote network control centres. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer and trip/close coils in the switchgear without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Employer.

5.23.1.5 The Contractor will have the option to choose different types of communication networks for the bay level and the process level based on IEC 61850. However, network topology and access mode shall be clearly indicated. The availability shall be maintained with suitable topology of ring, star or bus. The physical medium of those shall be glass fibre optics.

5.23.1.6 The IEDs for protection and control functions shall maintain high availability and reliability together with bay independence through extensive self-supervision and state-of-the-art technology. All IEDs shall be directly connected to the IEC 61850 bus and shall use only the IEC 61850 protocol for communication. No proprietary protocols shall be used. The SA system must have interoperability between IEDs of different manufacturers. Such shall be verified by test and submitted along-with the bid. The interoperability feature of SA must be verified during FAT also. System not having interoperability feature shall not be accepted.

5.23.1.7 The system shall be capable of having its computing power increased in the future through the addition of additional computing systems.

5.23.1.8 The system design life shall be not less than 20 years.

5.23.1.9 The capacity of the SA system shall be sufficient for the ultimate development of the substation as set out in the project requirements.

5.23.1.10 The SA Supplier shall demonstrate that the proposed system has been designed, installed and commissioned in accordance with the IEC 61850 standard and shall provide evidence of satisfactory service experience during the past 5 years.

5.23.1.11 The SAS shall have option for integration of Transformer Fire Prevention/Protection system integration. Necessary system configuration and switches shall be available for the said work.

5.23.2 Extension of existing SAS: The scope of work under this contract is to extend the existing SAS system for new bays. All necessary input and output shall be provided as per existing bays.

5.23.3 Compliance with Standards

For design and type-testing of the protection and control equipment, the following standards shall apply:

5.23.3.1 General List of Specifications

• IEC 60255:	Electrical Relays
• IEC 60038:	IEC Standard voltages
• IEC 68068:	Environmental testing
• IEC 60664:	Insulation co-ordination for equipment within low-voltage systems

• IEC 61850:	Standard for Substation integrated protection and control data communication

5.23.3.2 Detailed List of Specifications

• IEC 60068-2-3:	Test Ca: Damp heat steady state
• IEC 60068-2-30:	Test Db and guidance; Damp heat, cyclic
• IEC 60255-11:	Measuring relays and protection equipment
• IEC 60255-22:	Electrical disturbance tests for measuring relays and protection equipment:
• IEC 60255-22-1:	1 MHz burst disturbance test
• IEC 60255-22-2:	Electrostatic discharge test
• IEC 60255-22-3:	Radiated electromagnetic field disturbance test
• IEC 60255-22-4:	Fast transient disturbance test
• IEC 60255-11:	Interruptions to and alternating component (ripple) in D.C. auxiliary energising quantity to measuring relays
• IEC 60255-6:	Measuring relays and protection equipment
• IEC 60255-21:	Vibration, shock, bump and seismic tests on measuring relays and protection equipment:
• IEC 60255-21-1:	Vibration tests(sinusoidal)
• IEC 60255-21-2:	Shock and bump tests
• IEC 60255-21-3:	Seismic tests
• IEC 60255-0-20:	Contact performance of electrical relays
• IEC 60870-3 class 2:	Digital I/O, Analogue I/O dielectric tests
• IEC 60801-5/class 3:	digital I/O Surge withstand test
• IEC 60870-3/class2:	Radio interference test
• IEC 60801-4/4:	Transient fast burst test
• IEC 60801-2/4:	Static discharge
• IEC 60801-3/3:	Electromagnetic fields

5.23.4 Design and Operating Requirements

5.23.4.1 The SAS shall be suitable for operation and monitoring of the complete substation including future extensions. The offered products shall be suitable for efficient and reliable operation and maintenance support of the substations.

5.23.4.2 The SAS system shall have state-of-the art design, suitable for operation in a high voltage substation environment, follow the latest engineering practice; it shall ensure long-term compatibility requirements, continuity of equipment supply and the safety of the operating staff.

5.23.4.3 As shown in the SAS structure, protection is an integral part of the SAS, and protective relays shall be directly connected to the inter-bay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote control location.

5.23.4.4 Failure behaviour of the hardware and software functions shall be addressed, and related diagnostic and rectification working instructions shall be provided. The system's performance in case of failure of communication to NLDC, main and

redundant computer base workstations, central functions, data model, control and protection IEDs, station and bay level communication shall also be clearly addressed (shall be provided by the Manufacturer).

5.23.4.5 400kV, 230 kV and 132 kV substations, can also be controlled from the control panel installed in the control room. The following modes of operation shall be possible:

a. Emergency operation of breaker, disconnector, earthing switch etc. from the LCC.
b. Emergency operation of breaker, disconnector, earthing switch etc. from the backup mimic panel located in the new control room. Both, bay controller-guided and unguided operation shall be possible from this panel.
c. Normal operation of breaker, disconnector, earthing switch etc. from the station automation system's HMI located in the new control room.

5.23.5 Architecture & Components

5.23.5.1 The SAS design shall consider Rapid Spanning tree Protocol (RSTP) for ~~400kV,~~ 230kV & 132kV level. For 400kV or Higher voltage level, Parallel Redundancy Protocol (PRP) shall be applicable in all aspects. However same protocol shall be used throughout the substation ,in that case protocol for the highest voltage level shall be prevailed.

5.23.5.2 Following components have to be provided in the SAS architecture:

- Server cum operating workstation- 02 Nos
- Gateway computers with hardware based firewall including cyber security- 02 Nos
- Engineering workstation- 01 Nos
- Laser printer- 02 Nos
- Programmable Ethernet switches- as required
- GPS receiver- 01 Nos, 02 Nos (for PRP)
- Monitors- as per scope of supply
- Other accessories as shown in SAS architecture, scope of supply and as per system requirement

5.23.5.3 Operator workstations should have the teaming facility in the Ethernet LAN cards. Moreover, automatic stand by to hot conversion facility have to be available for both operator workstations. N-1 contingency criteria should be satisfied for all workstations, gateway computers, Ethernet switches and optical fiber links.

5.23.5.4 Common alarm unit shall be provided for notifying about important signals such as MCB status, device healthiness and tripping incidents of the feeders. The Unit should be capable of communicating with SAS.

5.23.5.5 NLDC provided Device ID should be used for the Identification of Switching Devices in the process display.

5.23.5.6 Audible alarm and buzzers must be provided with the SAS for important alarms and trip signals for the notification of the operators.

5.23.5.7 All devices of SAS workstations and gateway computers should be directly DC operated; alternatively AC operated devices supplied from substation DC sources

through inverter may be provided with redundancy and sufficient capacity. Necessary inverter have to be supplied by the contractor is such case.

5.23.5.8 Energy meters need to be connected to SAS and energy values displayed in SAS have to be extracted from Energy meters.

5.23.5.9 Automatic Voltage Regulator (AVR) should be directly IEC 61850 protocols supported and connected to SAS. Complete tap changing facility with parallel operation should be available in SAS for the Transformers of the substation.

5.23.5.10 In case of Parallel Redundancy Protocol- Engineering workstation, AVR will be connected to both networks of the topology.

5.23.5.11 Separate GPS receivers have to be provided for individual ring of the PRP network.

5.23.5.12 Status of Ethernet Switches, GPS Controllers, and Gateways shall be monitored and available on Operators Work stations.

5.23.5.13 DC changeover scheme should be established for all components of the architecture.

5.23.5.14 Status of DFDR and IED healthiness should be available in SAS.

5.23.5.15 33kV transformer incoming feeders of all substations should be operable from SAS.

5.23.5.16 A general arrangement of the Automation system shall include IEDs (Relay, BCU& meters), Ethernet switches, Server (Hot & Standby) with software, Operator Workstation, an Engineering PC, A 55'' LED monitor, Printers, Hot & standby Gateway with redundant switch & hardware firewall, cables (Fiber optic, Ethernet, copper) & connector, panels etc.

5.23.5.17 The workstation & server PC shall be merged into one unit in general& it is preferable one. However, segregated design is also acceptable within the same price; No additional price shall be claimed due to such design. The Ethernet switches shall have at least 20% spare switches for future use. All components of SAS shall be IEC 61850 compliant. The SAS shall be located in the Main Control Room unless otherwise specified. Final design shall be subject to approval of Employer. The Engineering PC shall have minimum core i7, latest generation, clock speed of 3.4 GHz,16GB RAM, 1 TB (RAID 1) SSD , 27'' display, touch screen facility etc.

5.23.6 Modes of Operation

The operator stations and specified remote users shall have the following operational modes, each password protected.

5.23.6.1 Monitoring: Ability to select graphic displays and lists for display only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.

5.23.6.2 Control: Selection of graphic display and lists. Able to acknowledge station and SAS alarms, complete controls, dressing etc. associated with normal real time of the control of the substation.

5.23.6.3 SAS Engineering: To provide all SAS monitoring functions, together with online facilities for program /database /format modifications and checking without the possibility of executing power system controls.

5.23.6.4 System Manager To provide access to all system functions, including assignment of passwords and system maintenance activities.

5.23.6.5 In addition, a facility to provide access to the numerical protection relays, change / modify relay settings & AVR parameters and fault recorder data shall be provided.

5.23.6.6 A series of passwords shall be personally assigned to operators in each of the above categories.

5.23.6.7 Substation operators shall have the possibility to log on to either substation workstation and to be allocated the appropriate mode of operation relevant to the password. SAS engineering work and access to the protection relay and disturbance reorder information shall generally be carried out at the engineering workstation or the remote master station.

5.23.6.8 All workstations and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

5.23.6.9 Similarly, an operator's manual entry applied at one workstation shall be immediately displayed at other workstations where this data is presented.

5.23.7 Project Specifications-

Specific functions required and boundary conditions of the SAS are detailed elsewhere in this specification. The following project-specific drawings are attached:

- Overall single line diagram
- General system architecture
- Location of substation buildings
- Control and operation principles
- Protection schemes

5.23.8 Vendor's Experience and Local Support

Only experienced and technically capable Manufacturers with minimum 5 years' experience in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred Manufacturers will be those who have experience in deliveries of the full scope of station automation systems and services. This experience has to be substantiated by means of reference installations being in service under similar environmental conditions for at least 5 years.The vendor shall provide long-term, i.e.10 years, guarantee of the complete SA system. In order to assess the Vendor's experience with similar projects, the Vendor is required to submit the following with his bid:

- Technical design specifications and description of SAS
- Catalogues and brochures of equipment and devices offered
- Reference list

The Vendor shall assure long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SAS equipment (not less than 10 years).

5.23.9 Quality Assurance and Inspection

Quality assurance of design and development, production, installation and servicing of material and workmanship shall be governed by ISO 9001. Supporting documents to prove ISO 9001 third party approvals shall be provided with the offer.

The SAS shall be pre-assembled and tested at the Vendor's workshop before shipment.

5.23.10 General System Design

The system shall be so designed that personnel without any background in microprocessor-based technology can operate the system easily after having received some basic training.

System control from the substation control room will be done by means of an industrial computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

1) Acquisition and plausibility check of switchgear status
2) Control of switchgear
3) Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays
4) Display of actual measured values (U, I, P, Q, f)
5) Display of events
6) Display of alarms
7) Display of trends
8) Sequence control functions
9) Disturbance records and fault location
10) System self-supervision
11) Hard copy printing
12) Dynamic busbar colouring

5.23.11 The offered SAS shall support remote control and monitoring from the NLDC via an industrial grade gateway with redundant CPU as well as redundant DC/DC converters. PC-based gateways which contain moving parts will not be accepted. The gateway should be designed for a life of at least 20 years. The gateway shall provide for communication to/from remote control centres via the IEC 60870-5-101 protocol. Even if the station PC is not available, it shall be possible to control the station from the NLDC as well as from the backup control panel in the individual bays with all interlocks. Interlocking in case of emergency (i.e. if the bay controller fails) should be waived locally by means of a switch with key lock by the Maintenance Engineer for all the switchgear.

5.23.12 Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimising maintenance time to repair.

5.23.13 As shown in the system drawing, the SAS shall be structured in two levels - station level and bay level. The data exchange between the electronic devices on both levels shall take place via an inter-bay bus using IEC 61850 standards. The entire station shall be controlled and supervised from the station level PC. It shall also be possible to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay fails. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz. NLDC, station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level.

5.23.14 Bay control and protection units shall be independent of each other and their functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station.

5.23.15 The SAS shall contain the following main functional parts:

1) Human Machine Interface (HMI) with process database
2) Gateway function for remote control via an industrial grade hardware
3) Dial-in facility / laptop workstation for protection relay parameterization, disturbance analysis and SAS fault analysis.
4) Data exchange between the different system components via high speed bus
5) Bay level devices for control, monitoring and protection
6) Bay-oriented local control and protection panels with mimic inserts
7) Facility for emergency operation of all the switchgear, if the bay controller fails (key / master key system).

5.23.16 The main process information of the station shall be stored in distributed databases. The system shall be based on a decentralised concept with bay-oriented distributed intelligence for safety and availability reasons. Functions shall be decentralised, object-oriented and located as close as possible to the process.

5.23.17 The substation monitoring/protection system shall supply data for maintenance, repair and remote parameter setting of protection and control devices in the switchyard.

5.23.18 In the event of a fault in the electrical network, the substation monitoring shall provide a quick means for collecting the relevant and critical data of the fault.

5.23.19 The monitoring system shall be suitable for the supervision and monitoring of all the secondary (IED) and primary devices in a substation including future extensions.

5.23.20 Maintenance, modification or extension of components shall not cause a shut-off of the whole station monitoring system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and to minimize maintenance.

5.23.21 It shall be possible to access all protection and control devices for reading the terminal parameters (settings). The setting of parameters or activation of parameter sets shall be restricted by password to the Protection Engineer.

5.23.22 One remote computer should be provided with access to the SMS and with different access levels. The required SMS software and application-specific firmware (for relay parameterization) shall be provided with associated tools and equipment. The required engineering tools and analyzing software shall also be provided/installed both in the station PC and the remote master analysis station. A backup copy of all the software shall be provided on CDs.

5.23.23 The SMS shall be capable of communicating with the remote master analysis station at the protection development branch through a modem over a dedicated or dial-up voice grade telephone line or microwave channel.

5.23.24 Flexibility and Scalability

The offered SAS concept shall be flexible and shall permit future extensions to be implemented easily. Preference will be given to those Suppliers who are in a position to provide protection and control devices that can be freely adapted to the required application functions.

5.23.25 System Hardware

5.23.25.1 Operator Station: The main operator station shall be based on an industrial PC hardware and high-resolution full-graphics screen with the Manufacturer's standard type-tested software operating under Windows NT environment. The Industrial

processor shall be high end like Intel Xeon or similar. An event printer and a hard copy printer shall be connected via a printer server and LAN to the operator station.

5.23.25.2 Dual station computers shall control the SAS and drive the work stations and other peripherals. One of the station computers shall operate the system in the "online" state while the other acts as a "redundant hot standby". The standby computer shall be continuously updated and shall immediately take over the SAS duties without interruption or transfer mechanism should the online operator workstation fail.

5.23.25.3 Disturbance records shall be analysed using the installed disturbance record analysis programmes. The disturbance records will be collected, over the inter-bay bus, from the connected IEDs by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of disturbance data or their upload in a pre-programmed manner. The event printer shall print events spontaneously as they arrive in the main operator station.

5.23.25.4 Each uploaded data report file shall be reported on one line that shall contain:

1) The event date and time
2) The name of the event object
3) A descriptive text
4) The state or value of the object

5.23.25.5 The information fields above shall be structured in columns for maximum readability.

5.23.25.6 The hard copy printer shall permit printing of any picture (or part thereof) from the station level PCs using easily accessible commands from the window menus.

5.23.25.7 The main station PCs shall be supplied by the station DC battery and a UPS system with a supply duration of not less than 30 minutes to supply the monitor and the printers.

5.23.25.8 A 16-window annunciator unit shall be directly connected to the main station PCs to monitor the same and also to annunciate common station abnormal/fault conditions.

5.23.25.9 Station Inter-bay Bus: The LAN connecting the industrial computer-based operator workstations and printers shall be Ethernet 802.3 LAN, protocol TCP/IP (10 Mbit./ sec or higher), and the physical medium shall be thin Ethernet or fibre optic bus, provided this LAN is kept within the confines of the control room.

5.23.25.10 The bay control and protection units shall be connected via glass fibre optic cables to a station inter-bay bus using industrial grade Ethernet switches. The station bus according to IEC 61850-8 is today mapped to MSS / Ethernet (with priority tagging and with 100 MS/s). The standard is not making any provision on the Ethernet communication infrastructure. To at least ensure a certain level of quality, performance and availability, the Ethernet switches and topology shall fulfil at least the criteria described below.

- Industrial-grade Ethernet switches that fulfill the hardened requirements concerning temperature, EMC and power supply (110 V DC from the station battery) suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection.
- The use of Ethernet hubs is not permitted as they do not provide collision-free transmission.

- The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g. for later system extension the utility has not to rely on one switch supplier only.
- External switches shall be supplied as they have the advantage that there is no interruption or reconfiguration of the Ethernet ring, if one or several bay devices are taken out of service.
- To increase reliability, the Ethernet switches shall have redundant power supply & shall be powered from two different station batteries.

5.23.25.11 Protection and Control IEDs and Local Back-up Control Mimic on 400kV, 230 kV Level

The bay control IEDs, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measure for operation via the HMI. They shall perform all bay-related functions such as protection, commands, bay interlocking, data acquisition, data storage, event and disturbance recording, and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear without any need for separate interposing equipment or transducers.

5.23.25.12 The numerical bay control IED shall be provided with a minimum of nine (9) configurable (current or voltage) analogue input channels and an adequate number of binary input & output channels which are galvanically isolated from the SAS. The channels shall also be individually separated from each other. HV switchgear and instrument transformers shall be directly connected to the bay level IED without any interposing equipment.

5.23.25.13 The devices shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 60255 to conform to the high requirements for operation on the secondary system of HV switchgear.

5.23.25.14 The 400kV, 230 kV and 132kV bay control & protection IED shall have the following minimum features:

1) a minimum of 9 configurable analogue channels
2) at least 32 binary inputs, 24 signal relays and 2 command relays
3) 16 LEDs on the front of the unit for indication
4) auto-reclose function
5) Synchrocheck function
6) power function which can be configured to measure forward or reverse, active or reactive power
7) four (4) independently settable parameter setting groups, settable/selectable locally or remotely via the HMI programme
8) 4 line local display units (LDU or front HMI) on the front of the relay which can display both input as well as measured quantities: frequency, phase currents, phase voltages, active power, reactive power, etc.
9) High-speed bus serial communication port as per IEC 61850 standards.
10) a sequence of events recorder with a buffer for 256 events and a resolution of 1 msec. The events to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to opto-coupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.

11) Disturbance recorder function which can record 9 analogue values, 16 binary signals and 12 analogue channels for internal measurement values. It shall be possible to trigger the disturbance recorder function by any internal or external binary signal or internal protective function.
12) comprehensive self-supervision
13) battery-free memory back-up of event and disturbance records
14) logic functions (AND, OR, bistable flip flop, etc.)
15) delay/integrator function

5.23.25.15 The numerical bay control IEDs shall be mounted together with all the relevant bay protective relays in cubicles of protection class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LEDs shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the substation.

5.23.25.16 The distributed backup mimic for local control shall be installed next to the bay controller IED, which can be used in case of maintenance or emergency or if bay control IED fails. Local bay control via the back-up control mimic on the control & protection cubicles shall incorporate the same user safety measures e.g. bay interlocking, synchrocheck, interlock override user guidance etc. as the station HMI. Local bay control shall be key-locked, and the control either from remote control panel (in the new control room),the station HMI or from remote shall be disabled if the local/remote selector switch on the back-up control mimic is in the "local" position.

5.23.25.17 The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function.

5.23.25.18 Faults in the bay control IED shall be indicated on a front HMI, and a message shall be sent to the station-level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

5.23.25.19 Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criterion must be maintained in worst case scenarios, also. Further, a single failure must not have any effect on the primary system, which is monitored and controlled.

5.23.25.20 Main protection shall be provided separately.

5.23.25.21 All IEDs shall have at least 5 years of successful proven experience in HV applications, and the MTBF for the offered units shall be provided.

5.23.26 Software Structure

5.23.26.1 The software package shall be structured according to the SAS architecture and shall be strictly divided into various levels. It shall be possible to extend the station with minimum possible effort. Maintenance, modification or extension of components of any feeder may not force a shutdown of the parts of the system which are not affected by the system adaptation.

5.23.26.2 Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the bid.

5.23.26.3 It shall be the responsibility of the Contractor to obtain any license required for the operation software. The Contractor shall indemnify the Client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

5.23.26.4

5.23.26.5 Station Level Software:

5.23.26.5.1 Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. The system shall contain a library with standard functions and applications.

5.23.26.5.2 Operating System

A Windows NT workstation operating system shall be used for the operator station as it supports several standard system features, e.g. support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardised, user-friendly look & feel HMI.

5.23.26.6 Bay Level Software

5.23.26.6.1 System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. Its lowest level shall assure system performance and contain basic functions, which shall not be accessible by the Application and Maintenance Engineer for modification. The system shall support the generation of typical control macros and a process database for user-specific data storage.

5.23.26.6.2 Application Software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They shall form part of a library. The application software within the control/protective devices shall be programmed in a functional block language.

5.23.27 System Testing

The Supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IEDs, applicable type test certificates shall be submitted.

The manufacturing phase of the SAS shall be concluded by a FAT. The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it

has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.
If the complete system consists of parts from various suppliers or some parts are already installed at site, the FAT shall be limited to sub-system tests. In such cases, the complete system test shall be performed at site together with the site acceptance test (SAT).

5.23.28 System Functions

5.23.28.1 Control Unit Functions

5.23.28.1.1 Control

The different high voltage apparatuses in the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:

1) Commands from different operator places, e.g. from the associated control centre (NLDC), station HMI, or the control panel (in control room) according to the operating principle
2) Select-before-execute commands
3) Operation from only one operator place at a time.
4) Operation depending on conditions from other functions, such as interlocking, synchro check, operator mode, or external status conditions.

The control function shall also include:

1) Prevention of double operation
2) Command supervision
3) Selection of operator place
4) Block/de-block of operation
5) Block/de-block of updating of position indications
6) Manual setting of position indications
7) Overriding of the interlocking function (Second key switch.)
8) Switchgear run time supervision

5.23.28.1.2 Status Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, be recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in case spontaneous position changes took place. Each position of an apparatus shall be indicated using two binary auxiliary normally closed (NC) and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

5.23.28.1.3 Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station-wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralised so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall take place via bay communication system.

An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

5.23.28.1.4 Measurement

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

5.23.28.1.5 Event and Alarm Handling

Events and alarms shall be generated either by the switchgear, by the control devices or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and shall appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The time tagging shall be done at the lowest level where the event occurs, and the information shall be distributed with the time tagging.

5.23.28.1.6 Time Synchronisation

The time within the SAS shall be set via a GPS clock receiver connected directly to the bay level LAN. The time shall then be distributed to the control/protective devices via the high speed optic fibre bus. An accuracy of ±1 ms within the station is required.

5.23.28.1.7 Synchronism and Energising Check

The synchronism and energizing check functions shall be distributed to the control and/or protective devices and shall have the following features:

1) Adjustable voltage, phase angle, and frequency difference.
2) Energizing for dead line - live bus, or live line - dead bus.
3) Settings for manual close command and auto-reclose command shall be adaptable to the operating times of the specific switchgear.

5.23.28.1.8 Voltage Selection

The voltages, which are relevant for the synchro check functions, depend on the station topology i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

5.23.28.2 HMI Functions

5.23.28.2.1 General

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log. The alarm list shall indicate persisting and fleeting alarms separately.

5.23.28.2.2 An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

5.23.28.2.3 The following standard pictures shall be available from the HMI:

1) single-line diagram showing the switching status and measured values
2) control dialogues
3) measurement dialogues
4) blocking dialogues
5) alarm list, station / bay oriented
6) event list, station / bay oriented
7) system status
8) checking of parameter setting

5.23.28.2.4 HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

1) selected object under command
2) selected on the screen
3) not updated, obsolete value, not in use or not sampled
4) alarm or faulty state
5) warning or blocked
6) update blocked or manually updated
7) control blocked
8) normal state
9) busbar colouring to show live & dead bus.

5.23.28.2.5 Process Status Displays and Command Procedures: The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive power as well as the positions of circuit breakers, isolators and transformer tap changers are displayed in the station single-line diagram.

5.23.28.2.6 In order to ensure a high degree of security against unwanted operation, a special "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen and all other switchgear shall be blocked. After the "execution" of the command, the operated switch symbol shall blink until the switch has reached its final new position.

5.23.28.2.7 The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated The interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

5.23.28.2.8 After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

5.23.28.2.9 System Supervision Display

The SAS shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status

of the entire substation including all switchgear, IEDs, communication links, and printers at the station level etc.

5.23.28.2.10 Reports

The SAS shall generate reports that provide time-related information on measured values and calculated values. The data displayed shall comprise:

Trend reports:

1) day (mean, peak)
2) month (mean, peak)
3) semi-annual (mean, peak)
4) year (mean, peak)

Historical reports:

1) day
2) week
3) month
4) year

5.23.28.2.11 There must be provision of automatically generated periodic reports (such as, 15mins/30mins/1hr etc) of all analog data (such as Current, Voltage, Real Power, Reactive Power, Power Factor, and Frequency).

5.23.28.2.12 It shall be possible to select the displayed values from the database online in the process display. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

5.23.28.2.13 This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

5.23.28.2.14 Trend Display (Historical Data): A trend is a time-related follow-up of process data. The analogue channels of all connected bay level devices ~~on the 132-kV level~~ shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum.

5.23.28.2.15 It shall be possible to change the type of value logging (direct, mean, sum, or difference) online in the window. It shall also be possible to change the update intervals online in the picture as well as the selection of threshold values for alarming purposes.

5.23.28.3 Event List

5.23.28.3.1 The event list shall contain events, which are important for the control and monitoring of the substation. The time has to be displayed for each event.

5.23.28.3.2 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.

5.23.28.3.3 A printout of each display shall be possible on the hard copy printer.

5.23.28.3.4 The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer. The information shall be obtainable also from printed event log.

5.23.28.3.5 The chronological event list shall contain:

1) position changes of circuit breakers, isolators and earthing devices
2) indication of protective relay operations
3) fault signals from the switchgear
4) violation of upper and lower limits of analogue measured value

5) loss of communication

5.23.28.3.6 Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

1) date and time
2) bay
3) device
4) function
5) alarm class

5.23.28.4 Alarm List

5.23.28.4.1 Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. Date and time of occurrence shall be indicated.

5.23.28.4.2 The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

1) The alarm date and time
2) The name of the alarming object
3) A descriptive text
4) The acknowledgement state

5.23.28.4.3 The operator shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

5.23.28.4.4 Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example due to bad contacts or intermittent operation.

5.23.28.4.5 Filters for selection of a certain type or group of alarms shall be available as for events.

5.23.28.5 Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as

1) type of blocking,
2) authority
3) local / remote control
4) NLDC/SAS control
5) errors,
6) etc.,

shall be displayed.

5.23.28.6 Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

5.23.28.7 User Authority Levels

5.23.28.7.1 It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

1) Display only
2) Normal operation (e.g. open/close apparatus)
3) Restricted operation (e.g. by-passed interlock)
4) System administrator

5.23.28.7.2 For maintenance and Engineering purposes of the station HMI, the following authorization levels shall be available:

1) No Engineering allowed
2) Engineering/configuration allowed
3) Entire system management allowed

5.23.28.7.3 The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

5.23.28.7.4 Controlling authority should be provided of NLDC control, Control from SAS HMI, Bay Controller, Mimic and Local Control Cubicle. Selected authority control must be displayed in the SAS monitor.

5.23.29 System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the substation shall be according to the levels specified below:

Function	Typical values
Exchange of display (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s
Presentation of an analogue change in the process display	< 1 s
From order to process output	< 0.5 s
From order to update of display	< 1.5 s

5.23.30 System Reliability

The SAS system shall be designed to satisfy very high demands for reliability and availability concerning:

1) Solid mechanical and electrical design
2) Security against electrical interference (EMI)
3) High quality components and boards

4) Modular, well-tested hardware
5) Thoroughly developed and tested modular software
6) Easy-to-understand programming language for application programming
7) Detailed graphical documentation, according to IEC 61131-3, of the application software
8) Built-in supervision and diagnostic functions
9) After sales service
10) Security
11) Experience of security requirements
12) Process know-how
13) Select before execute at operation
14) Process status representation as double indications
15) Distributed solution
16) Independent units connected to the local area network
17) Back-up functions
18) Panel design appropriate to the harsh electrical environment and ambient conditions
20) Panel grounding to provide immunity against transient ground potential rise

5.23.31 Configuration Tools

5.23.31.1 The configuration of the station HMI shall be made using the operator station working in Windows NT environment. The various functions shall be customised by easy to use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process database and adaptations of the communication configuration data.

5.23.31.2 A portable personal computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

5.23.31.3 The PC based service & support system shall be used for the following purposes:

1) System configuration
2) System testing
3) Help functions
4) Program documentation
5) Down- and up-loading of programs
6) System commissioning
7) Data base management
8) Changing peripheral parameters

5.23.31.4 The service & support system shall be able to monitor data in the running substation control system and to present changing variables on the display screen in graphic representation.

5.23.32 Documentation

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

1) List of drawings

2) Control room layout
3) Assembly drawing
4) Single line diagram
5) Block diagram
6) Circuit diagram
7) List of apparatus
8) List of labels
9) Functional design specification (FDS)
10) Test specification for factory acceptance test (FAT)
11) Logic diagram
12) List of signals
13) Operator's manual
14) Product manuals
15) Calculation for uninterrupted power supply (UPS) dimensioning
16) High-quality SCD file.

(Please refer to chapter 5.23.25.11 which specifies the requirements of the local back-up control mimic. This back-up control shall be used during emergency conditions, or bay control IED is out of service or when control from HMI workstation or from remote NCC has been lost.)

5.23.33 Indicating Meters in Local Back-up Control Panels

Each circuit shall be equipped with Indicating meter for measurement of three phase currents, voltages, frequency, power factor, active and reactive power. Repeat pulse outputs are to be provided from all energy meters, where specified.

5.23.34 Availability Calculations

The Contractor shall submit availability calculations for the offered substation automation system.

5.23.35 Testing and Commissioning

Testing and commissioning of the SAS must be performed by the engineer from manufacturer's side. The contractor may have to provide evidence of the manufacturer's authentication regarding the personnel and his experience in the relevant field.

5.24 Trip Circuit and Power Supply Supervision

5.24.1 Trip circuit supervision relays shall be provided to monitor each of the trip circuits of circuit breakers in the relay panel and each relay shall have sufficient contacts for visual/audible alarm and indication purposes.

5.24.2 The trip circuit supervision scheme shall provide continuous supervision of the trip circuits of the circuit breaker in either the open or closed position and independent of Local or Remote selection at the local operating position.

5.24.3 The trip circuit supervision scheme shall operate satisfactorily and correctly under such conditions.

5.24.4 Relay elements shall be delayed on drop-off to prevent false alarms during faults on dc wiring on adjacent circuits, or due to operation of a trip relay contact.

5.24.5 Series resistances shall be provided in trip circuit supervision circuits to prevent mal-tripping of a circuit breaker if a relay element is short circuited.

5.24.6 Relay alarm elements should be equipped with self-resetting flag indicators.

5.24.7 Where specified, time delayed power supply supervision relays shall be provided to monitor the duplicated d.c. power supplies for tripping, closing, CB fail, Busbar protection etc. within a relay panel. An alarm shall be given if either supply voltage falls below 70% of nominal voltage for a period in excess of 3 secs. The relay shall be equipped with a self-resetting flag indicator, and shall be suitable for continuous operation at 125% of nominal d.c. voltage. The relay used shall be of Europe/USA origin or other eligible countries with equivalent quality.

5.25 Busbar Voltage Selection

Where required, selected voltage references, one for each busbar, shall be employed for all indications, metering, protection and synchrocheck where appropriate. The correct voltage selection for the requirements of each circuit according to the busbar to which it is connected shall be obtained by internal selection in the BCU or Relay by directly connecting voltage transformers. External busbar VT selection through auxiliary relays will not be accepted.

5.26 Synchrocheck

5.26.1 Synchrocheck Scheme: Synchrocheck facilities are required at all circuit breakers controlling feeder circuits and bus coupler circuits, and LV circuit breakers controlling transformers.

5.26.2 The system provided under the Contract is to be to the approval of the Engineer and is to be such that the synchrocheck circuit must be established before the circuit breaker can be closed. Synchrocheck function will be performed by BCU (Bay Control Unit) for controlling from SAS or BCU. Synchrocheck function will be checked by Protective relays as shown in attached interlocking logics for controlling from Mimic.

5.26.3 Synchrocheck relays shall check the phase and magnitude and slip frequency of the voltage difference across the open circuit breaker with contacts connected to prevent inadvertent manual closing outside acceptable limits.

5.26.4 It shall be possible when closing via HMI Workstation or remote NCC to close a circuit breaker when both the line side and the busbar side of the circuit are dead by bypassing the synchrocheck relay. The dead line/dead busbar check shall be made by means of 3 phase undervoltage devices. The primary circuit shall be deemed to be dead if the voltage of all three phases is less than 20% of nominal voltage.

5.26.5 It shall only be possible to operate on one circuit at a time.

5.27 Interlocking and Control Authority

5.27.1 Independent and identical interlocking/blocking conditions have to be established for Mimic and BCU control. Interlocks in Local Control Cubicle (LCC) will also be same in case of GIS.

5.27.2 For mimic control, interlocking/blocking conditions will be hardware based and established in CRP by taking the statuses of relevant devices to CRP. Contact

multiplier relays can be used for the purpose. Wiring in the switchyard among the devices will not be accepted.

5.27.3 For controlling from BCU, interlock will be software based and established in BCU. Hardware based interlocks will never be bypassed in any mode of operation.

5.27.4 Interlock for maintenance mode will be established in LCC for GIS.

5.27.5 Interlock bypassing option should be available in Control Panel; should also be available in LCC in case of GIS.

5.27.6 More than one device will not be allowed for operation at the same time.

5.27.7 CB internal blocking such as Gas pressure lock-out, spring discharge etc will be applicable for all modes of operations.

5.27.8 Control Authority Switch shall be installed in Control Panel having 4 (four) independent positions: Off, Mimic, BCU and Remote. The switch can be in only one position at any given time.

5.27.9 Interlocking logics and control authorities must comply with the attached Interlocking Logic drawings.

5.28 Diagrams

The Contractor shall submit schematic diagrams for consideration of the Engineer within six months of the contract commencement date. Prior to preparation of schematic diagrams, the Contractor shall provide single line, block and logic diagrams in order to agree the circuit schemes and operating modes.

The Contractor will be provided with a set of drawings for Substations as soon as possible after award of Contract. As part of the contract documentation, the Contractor shall provide integrated sets of complete drawings (schematic and wiring diagrams and cable schedules etc.) for protection and substation automation
Protection SLD, Trip matrices and Interlocking logic block diagrams have to be integral part of schematic drawings of each Control and Protection panel.

5.29 Current Transformer Calculations

The Contractor shall submit to the Engineer detailed calculations substantiating the parameters of the current transformers he proposes to provide. They shall be presented within six weeks of the contract commencement date.

5.30 Energy Meter (Tariff Metering)

For each substation, the Contractor has to foresee one (or more) separate Metering cubicle(s). During the Design stage, the Contractor has to propose the final solution, which will be subject of the Employer’s final approval

SL. No.	Description	Unit	PGCB's requirements	Bidder's data
1	Manufacturer's name		CEWE/Elster/Landis+Gyr/EDMI/SEL or equivalent	
2	Country of Origin		France/UK/USA/Switzerland/Sweden/ Germany/EU or equivalent	
3	Model		Should be filled up by bidder	
4	Meter type		Numerical, programmable, multi-function, IEC 61850 complaint	
5	Display language		English	
6	Connection type		CT/VT operated, 3-phase, 4 wires, solidly grounded neutral	
7	Installation		Indoor installation	
8	Type of socket		To be mentioned	
9	Number of element	Nos	3 (three)	
10	Number of terminals	Nos	At least 10 (ten)	
11	Current range	A	1 to 10, user programmable	
12	Starting Current	A	0.1% of nominal	
13	Continuous Thermal current rating	A	1.5*In or higher	
14	Short time thermal rating	A	10*In or higher for 1sec	
15	Voltage range	V AC	50 to 82.5 (P-N) or higher range, Burden-10MΩ	
16	Overload voltage	V AC	1.3*Vn, continuous	
17	Burden			
	17.1 Current Circuit	VA/phase	< 0.1 @ 1A, < 0.5 @ 5A	
	17.2 Voltage Circuit (with auxiliary power)	VA/phase	< 0.1	
	17.3 Voltage Circuit (with self power)	VA/phase	< 6VA	
18	Auxiliary supply range		Dual Power Supply: i. 80V to 240V AC/DC or higher range ii. Self Power with VT voltage (80V to 130V AC)	
19	Operating frequency		50Hz (±5%)	
20	Measuring mode		True 4 quadrant	
21	Accuracy class		0.2 for kWh, 0.5 for kVARh	
22	Losses at nominal load		To be mentioned	
23	Local communication		DLMS, RS232/RS485/Ethernet	
24	Remote communication		Standard metering protocol, MODBUS; Communication facility to Network Control Center should be available	

SL. No.	Description	Unit	PGCB's requirements	Bidder's data
25	Software interfacing facility with PC		Should be available	
26	Software requirement		1. Should be able to configure and monitor with user friendly PC-based tool. 2. Necessary software for configuration and parameterization has to be supplied free of cost and without any time-bound license	
27	Password protection		Should be available for programming, configuration and read out meter data	
28	Meter sealing condition		Hermatically or Ultrasonic welded	
29	Display options		Built-in HMI LCD display, configurable display, including meter ID, power quadrant display	
30	Integration period		30 (thirty) minutes	
	Resetting period		1 (one) month	
	Cumulative MD transfer		Built-in	
	Cycle Timing device		Built-in	
31	Normal display list		● Complete LCD test, Present date, Present time ● Current billing total kWh-Del, Current billing total kWh-Rec ● Current billing total kVARh-(Q1+Q4), Current billing total kVARh-(Q2+Q3) ● Current billing maximum kW-Del, Current billing maximum kW- Del Date, Current billing maximum kW-Del Time, Current billing cumulative kW-Del ● Current billing maximum kW-Rec, Current billing maximum kW-Rec Date, Current billing maximum kW-Rec Time, Current billing cumulative kW-Rec ● Phase A voltage, Phase B voltage, Phase C voltage ● Phase A current, Phase B current, Phase C current ● Phase A voltage angle, Phase B voltage angle, Phase C voltage angle	

SL. No.	Description	Unit	PGCB's requirements	Bidder's data
			● Phase A current angle, Phase B current angle, Phase C current angle ● System PF-arithmetic, Line frequency	
32	Alternate mode display list		● Complete LCD test, Present date, Present time ● Current billing total kWh-Del, Current billing total kWh-Rec ● Current billing total kVARh-(Q1+Q4), Current billing total kVARh-(Q2+Q3) ● System PF-arithmetic, Line frequency	
33	Online testing facility		Should be available with online CT shorting facility with security sealing provision	
34	Data storage		At least 32MB of nonvolatile memory for data storage and capable of simultaneously record 4 load profile recorders x 8 channels for at least 90days at 30 minute intervals.	
35	Data logging and event recording		Should be available	
36	In built clock		Should be available	
37	Provision of GPS synchronization		Should be available	
38	Additional Features (Optional)		i. Power Quality Measurement (At least 1 GB of memory, 192 channels of LDP, 24kHz waveform, 600 VSSI summary events, Wave View, Flicker, Power Harmonics and Interharmonics, Total Harmonic Distortion) ii. Necessary software for accessing the mentioned features should be provided without any time-bound license.	
39	Environment requirement			
	39.1 Ingress protection		IP54 or better	
	39.2 Operating temperature		-10ºC to +60ºC	
	39.3 Storage temperature		-40ºC to +80ºC	
	39.4 Humidity range		0% to 95%, non-condensing	

SL. No.	Description	Unit	PGCB's requirements	Bidder's data
40	Weight of the meter		To be mentioned	
41	Dimension of the meter		To be mentioned	
42	Outline, drawing and leaflets		To be provided	
43	Performance curves for balanced and unbalanced load		To be mentioned	
44	Year of manufacture		To be mentioned	
45	Minimum Battery Service life and shelf life	Years	10 (ten) & 15 (fifteen) respectively	
46	Meter service life	Years	15 (fifteen)	
47	Reference standard		Relevant ANSI/IEC standard	
48	Warranty	Years	3 (three)	
49	Type test certificate		Should be provided	

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 6

AUXILIARY POWER AND CONTROL CABLES

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AUXILIARY POWER AND CONTROL CABLES

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SECTION 6

AUXILIARY POWER AND CONTROL CABLES

6.1 SCOPE

A complete cabling system for the substation 415/230 V auxiliary power requirements and the control and protection multicore cabling shall be designed, provided, installed and commissioned by the Bidder as specified in the Project Requirements and schedules. All ducts, cable racking and supports are to be supplied under the Contract. The Bidder shall, furnish satisfactory evidence as to the competence of the electricians and jointers he proposes to employ on the cable installation and jointing works.

6.2 GENERAL DESCRIPTION OF INSTALLATION

The complete cabling installation, including that associated with control and instrumentation, shall be managed by the Bidder, who shall be responsible for design, procurement, installation and works/site testing of the whole installation.

The Bidder shall employ a cabling computer program to facilitate the above and the Bidder shall describe in his Tender the cabling management procedures he will adopt. A cable scheduling system will be imposed by the Employer.

The Bidder shall provide an installation in accordance with the best modern practice and complete in every detail for continuous operation.

Cabling areas will include those which have natural ventilation. Cabling shall therefore be designed for the maximum ambient temperatures expected.

To cater for future requirements, adequate provision shall be made for the associated cables in respect of trench sizes, space for future racks or trays and numbers of cables permitted in areas or spaces required for future equipment.

The Bidder shall submit to the Employer drawings for approval showing the proposed cable routes, crosssections of the trenches and arrangements of the cable racks and trays.

The Bidder shall prepare and provide all necessary cable schedules. The cable numbering system to be used shall be advised to the Bidder and this system shall be followed.

The Bidder shall provide all necessary power, multicore and communications cables required as required and specified in the Project Requirements.

6.3 STANDARDS

The cables shall comply with British Standards or International Electrotechnical Commission (IEC) Standards and Recommendations, or any other internationally

recognised standards, subject to the approval and acceptance of the Employer.

6.4 CABLE INSTALLATION

6.4.1 General

The cabling system shall be designed to incorporate maximum practical security, to ensure that an incident such as fire causing loss of cable circuits in any one route would at worst result in the interruption in operation of one unit only. Cables with reduced fire propagation characteristics shall be provided.

Cables shall be satisfactory for operation under the atmospheric and climatic conditions prevailing at the site and under such variations of current, voltage and frequency as may be met under fault and surge conditions on the system.

Cables shall be derated to allow for the likely number of cables following a given route.

The methods of installation shall be as follows:

(a) In concrete trenches
(c) In ducts
(d) On cable racks, trays or ladders

Control and instrumentation cables shall be screened/shielded to minimise interference, where necessary.

6.4.2 Installation Criteria

Specific requirements shall be as detailed in the Project Requirements.

System security shall be achieved by ensuring that cables are segregated or separated from each other as appropriate. Segregation shall be achieved by laying cables associated with any one high voltage circuit of a pair on separate trays or racks at least 600mm apart from the cables of the other of the pair with an airspace, but not necessarily a physical barrier, between them.

In general, to minimise interference, control cables and instrumentation cables shall be separated from power cables.

The following group classifications will be allocated for each cable:

i) Group A: Single core power cables,
ii) Group B: Multicore power cables,
iii) Group C: Multicore control cables and protection cables,
iv) Group D: multipair control and instrumentation or indication cables.

In general, single core (Group A) and multicore (Group B) power cables shall be allocated to separate racks. In a similar manner, multicore control (Group C) and multipair (Group D) instrumentation cables shall generally be allocated to separate

trays.

There shall generally be a minimum separation of 600 mm between instrumentation cables (Group D) and power cables (Groups A and B), and a minimum separation of 300 mm between control cables (Group C) and power cables (Groups A and B). However, both these separation distances may be reduced where the two types of cable only run in parallel for a limited distance, provided the Bidder demonstrates that the level of interference resulting will not be detrimental to the operation of the equipment concerned.

6.4.3 Reduced Fire Propagation

A cable installation with reduced fire propagation characteristics shall be provided, utilising cables with organic compounds which are capable of extinguishing or considerably reducing the spread of flame along the cable.

Consideration shall also be given to ensuring that the minimum toxic or corrosive products are given off on combustion of any organic component used in cable construction.

6.4.4 Type Approval

Cables and accessories for use at all voltages shall have satisfactorily passed type approval tests equal to those required by the International Electrotechnical Commission or equivalent, and details for the cable designs offered shall be given in Schedule E of Particulars and Guarantees.

The Bidder is to certify that the cables and/or accessories offered will be identical in all essential particulars in respect of design, materials and workmanship with the cables and/or accessories for which type approval certificates are offered in support of his tender. The Bidder shall also ensure that all materials used will be subjected to and shall have satisfactorily withstood such tests as are customary in the manufacture of the types of cables specified. Records of such tests shall be available for inspection, if required by the Employer.

6.4.5 Cable Sizing and Routing

The Bidder shall be responsible for all cable sizing and routing design, procurement, installation and testing.

Proposals for the following aspects of cable design shall be submitted for approval:

- Routing cables along the shortest route compatible with segregation /separation and capacity limitations

Sizing cables in accordance with length grouping, ambient temperature and current rating

Recording estimated lengths and later measured lengths for each cable

Progressing the cable installation

- Producing and progressing cable schedules, cable termination schedules, and

support steelwork schedules and drawings

All necessary derating factors shall be applied when sizing cables, to allow for maximum ambient temperatures, soil temperatures, values of thermal resistivity of soil, and grouping as necessary.

Due allowance shall be made for the method of installation, depth of laying, spacing and grouping factors.

All power cables shall be adequately rated to withstand the thermal and magnetic effects of shortcircuit fault currents equivalent to the short circuit fault rating of the associated switchgear, except when advantage can be taken of the peak current limiting effects of MCCB's and fuses. Screens and/or outer sheaths shall be designed to carry the full ground fault current.

The shorttime rating of all transformer and interconnector feeders shall correspond to the maximum shortcircuit conditions and be based on the previous maximum continuous rating operating temperature, followed by the initial asymmetric peak current, followed by the thermal steady state r.m.s. fault current for the total duration required for the associated main and backup protection to operate and isolate the circuit. When protected by a circuit breaker which is not of the current limiting type, the cable shall withstand the maximum fault current, including asymmetric peak, for at least 3 seconds without damage.

For 415V motor supply cables the rating shall be based upon the duration of the letthrough current of the associated main circuit breaker or fuse protection. The fault currents considered shall not include for the reduction due to the impedance of the cables concerned.

Maximum conductor temperatures permissible during the passage of shortcircuit current shall be in accordance with cable manufacturer's recommendations and joints and terminations shall be designed to match the cable characteristics.

For all alarm, control, indication, instrumentation, metering and protection cables, the Bidder shall determine the impedances, load burdens and other requirements of the cabling and associated equipment and shall provide cabling for satisfactory operation. Particular attention shall be given to protection circuits and the Bidder shall ensure that satisfactory operation will be achieved under overload or short circuit conditions on the system.

The Bidder shall furnish copies of calculations and other details to show how the ratings and crosssection areas of all cables have been obtained and the derating factors for which allowance has been made. Where a cable is routed through differing types of installation conditions, the condition giving the lowest cable rating shall determine the cable size.

The sizes of all cables shall be submitted to the Employer for approval and the Employer may require the Bidder to increase the crosssectional area of the conductor to ensure that the required current carrying capacity and performance is obtained. All

such changes shall be made by the Bidder without extra cost.

6.5 CABLE CONSTRUCTION

6.5.1 Oversheaths

All cables shall have a black flame retardant low smoke PVC oversheath material, to meet the fire retardant characteristics of BS 4066 and IEC 60332.

PVC sheathing shall have flame retardant properties such that the Oxygen Index is not less than 30 when tested in accordance with A.S.T.M. D286377. Test certificates stating measurement values for sample drum lengths of cable shall be provided.

The external surface of the oversheath shall be embossed along two or more lines approximately equally spaced around the circumference with the words 'ELECTRIC CABLE' in English. Figures for the relevant voltage grade, together with manufacturer's name, shall be embossed on the oversheath.

The letters and figures shall be raised and shall consist of upright block characters. The maximum size of the character shall be 13 mm and the minimum size 15% of the approximate overall diameter of the cable. The gap between the end of one set of embossed characters and the beginning of the next shall not be greater than 150mm.

The minimum thickness of oversheath shall not fall below the manufacturer’s stated value by more than 0.2mm plus 20 percent.

A means of identifying the manufacturer shall be provided throughout the length of the cable.

6.5.2 Armouring

All multicore cables shall be provided with galvanised steel wire armour. Singlecore cables shall have copper or aluminium wire or tape armouring.

The armour shall be protected by an overall PVC or plastic sheath.

6.5.3 Laying up

The cores of multicore cables shall be laid up with a right hand direction of lay. Where necessary, nonhygroscopic fillers, which may be applied integrally with the bedding, shall be used to form a compact and circular cable.

6.5.4 Cable Drums

Cable drums shall be nonreturnable and shall be made of timber, pressure impregnated against fungal and insect attack, or made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens.

Each cable drum shall bear a distinguishing number on the outside of one flange.

Particulars of the cable, i.e. voltage, conductor size and material, number of cores, type, length, gross and net weights shall also be clearly shown on one flange. The direction of rolling shall be indicated by an arrow on both flanges. The method of drum marking shall be to the Employer's approval.

Cable spare lengths shall be wound on to steel drums before they are handed over to the Employer's stores.

6.5.5 Sealing and Drumming

Immediately after the Works tests, both ends of each cable length shall be sealed by means of a shrinkable cap and the end projecting from the drum shall be adequately protected against mechanical damage during handling. The ends of each drum length of multicore cables shall be masked red and green in accordance with BS 6346 or BS 5467.

6.5.6 Spare Cable

Spare cable and accessories, as detailed in the schedules, are required to be included in the Contract.

6.5.7 Jointing Accessories

Cables shall be installed in continuous lengths and straight through jointing between shorter lengths will not be permitted.

Jointing accessories shall include all necessary internal and external fittings, insulating materials, soldering metal, glands, filling and drain plugs, armour clamps, earth bonding terminals and filling compounds as appropriate.

Mechanical glands for the termination of elastomeric or thermoplastic insulated cables into straightthrough joints and termination accessories shall meet the requirements of BS 6121 and shall be correctly designed for the termination of the armouring. The gland shall not only adequately secure the armour to provide efficient electrical continuity but shall also provide a watertight seal between the oversheath and the inner extruded or taped bedding to prevent the ingress of moisture. All glands shall be fitted with a substantial earth bond terminal.

The armour clamping device shall be capable of clamping the cable armour so that the clamp withstands any short circuit current from the armour wires, through the gland body to the integral bonding connector.

Sealing end porcelains shall be free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth and hard, completely cover all exposed parts of the porcelain and for outdoor types shall be a uniform shade of brown.

Porcelains must not engage directly with hard metals and, where necessary, gaskets shall be interposed between the porcelain and the fittings. All porcelain clamping

surfaces in contact with gaskets shall be accurately ground and free from glaze.

Sealing ends and fittings shall be unaffected by atmospheric conditions, proximity to the coast, fumes, ozone, acids, alkalis, dust or rapid changes of air temperature between 15ºC and 65ºC under working conditions.

6.6 TYPES OF CABLE

6.6.1 Low Voltage Cables

These cables shall be in accordance with IEC 60502 with a voltage rating of 0.6/1kV.

These cables shall have stranded copper conductors.

Insulation shall be XLPE with an operating temperature of 90ºC.

6.6.2 Control Cables and Instrumentation Cables

6.6.2.1 General

Two types of cable shall be provided for the control and instrumentation cabling. The first is multicore cable with stranded (7/0.67mm wires) copper conductors of 2.5sq.mm. which is suitable for voltages up to 300V to ground a.c. or d.c. and currents up to 5A. These cables shall be used where a low impedance is essential i.e. the secondary wiring of current or voltage transformers and for circuit breaker or contactor controls.

The second type designated "signal cable" is defined as those cables carrying milliamp, analogue or digital signals at low voltage levels (50V d.c. maximum) used on instrument and Logic Transmission Systems. These cables shall be multiple twisted pairs, screened and PVC covered with conductors sized 0.5mm^2 minimum (1/0.8mm or 1/0.9mm diameter). The use of cable cores shall be such that each plant analogue signal is transmitted in a twisted pair. Under no circumstances shall the signal positive be in a different twisted pair to the negative. 20% spare capacity shall be included in all multiple twisted pair cables. The combinations of multiple twisted pair cables used throughout the Plant shall be restricted to 2, 5, 10, 20, 30, 50 and 100 pairs.

Inductive interference between primary and secondary cables due to load, switching or unbalanced fault conditions associated with the primary circuit shall be avoided. The more sensitive telephone, communication, analogue and digital circuit cables shall be spaced at least 600mm from power cables.

6.6.2.2 Multicore Control Cables

Cables shall comply with the construction here above and shall have crosslinked polyethylene (XLPE) insulation.

All cables shall be provided with a low smoke PVC oversheath.

Multicore control cables shall be generally in accordance with IEC 60502 with voltage rating 0.6/1 kV, except that 2.5 mm^2 copper conductors shall be stranded (7/0.67mm wires). Standard designs shall be for cables with 2, 3, 4, 7, 12, 19, 27 and 37 cores, and single strand conductors will be accepted at 1.5 mm^2

All these cables shall have galvanised steel wire armouring.

These cables shall be used where a low impedance is essential, e.g. for the secondary wiring of current and voltage transformers and for circuit breaker and contactor control circuits.

6.6.2.3 Multipair Instrumentation Cables

Multipair instrumentation cables shall be provided in accordance with industry standards.

These cables shall have solid copper conductors, typically of 0.9 mm diameter laid in twisted pairs, triplets or quads. The cables shall be polyethylene or XLPE insulated. They shall have galvanised steel wire armouring.

Cables shall be provided with either an overall metallic tape screen or individual tape screens round each conductor bundle to reduce interference from adjacent circuits.

These cables shall be used for circuits with a voltage rating not exceeding 125 V to earth and a current rating not exceeding 20 mA, where considerations of interference and crosstalk are of great importance. Typical applications include communications, computer signals, transducer circuits and alarms.

6.6.2.4 Oversheaths

All the cable types above shall have a black flameretardant low smoke PVC oversheath. In normally manned locations, especially the control building, cables shall have a low smoke, zero halogen oversheath, so as to minimise the generation of smoke and corrosive acid gases in the event of a fire.

6.6.2.5 Telephone Type Cables (TWPVC)

i) Construction

Multipair cables with l/0.9mm tinned copper conductors complying with IEC 60228, PVC insulation, individual twisted pairs, PVC bedding, single wire armoured and low smoke PVC sheathed overall.

ii) Insulation

PVC insulation shall be "Hard Grade" to BS 6746 with a radial thickness of 0.7mm nominal 0.57mm minimum. Minimum insulation resistance per 1000 metres of conductor at 20□C shall be 10,000 Megohms.

iii) Laying Up

The insulated conductors shall be uniformly twisted together with a right hand lay to form a pair. The length of lay is not to exceed 150mm and the lays for each adjacent pair are to differ from one another in length. In any case, the length of lay of the pairs shall be such that any crosstalk from pair to pair is the least possible.

iv) Core Identification

The insulation of the cores shall be colour coded in accordance with IEC 601892 for 20 unique cabling elements (pairs) as described in Appendix A of IEC 601892.

6.6.2.6 Pilot Cable

Telephone type cable laid in the ground alongside HV power cables shall take into account the effects of induced voltages.

6.7 STRAIGHT THROUGH JOINTS

Each cable shall be run in one continuous length. Straightthrough joints will not be permitted.

6.8 GENERAL METHODS OF CABLE INSTALLATION

The arrangement of cables and the methods of laying shall be approved by the Employer. Cables shall be installed by the following methods only:

- In concrete trenches
- In ducts
- On cable racks, trays or ladders

Concrete trenches shall be provided in switchrooms. Cables shall be installed in a manner which permits the required ratings and with due regard to the number of cables following a given route, including future plant extensions.

All cables routed under roads and access ways usable by vehicular traffic shall be installed in ducts.

At all such crossings spare ducts shall be installed; the number of spare ducts shall be two, or 20% of the total number of ducts installed at each crossing, whichever is greater.

Mechanical protection to the Employer's approval shall be installed at all points where the cable is vulnerable to mechanical damage. Locations where this protection shall be installed shall include all points where cables pass through a wall, floor, side or top of a cable trench.

Cables shall be installed in such a manner as to avoid undue risk of damage during installation. The Bidder shall provide all necessary rollers and supports, and bending radii shall comply with the recommendations of cable specifications and be to the approval of the Employer.

Sunshields shall be provided in all locations where the cable would otherwise be subjected to direct sunlight.

6.9 CABLES DRAWN INTO DUCTS

Ducts and pipes 35mm minimum in excess of cable diameter, shall be supplied and installed by the Bidder in accordance with the building and civil works section.

Ducts shall be of rigid PVC and shall be surrounded by l50mm minimum thickness of concrete.

Before pulling cables through ducts, the Bidder shall remove any loose material from the ducts, and prove them by drawing through a mandrel of slightly less diameter than the duct. Any lubricant used shall have no deleterious effect on the cables.

Any ducts or pipes not used shall be sealed by plugs (detail subject to approval) supplied by the Bidder before backfilling.

The ducts shall be water and vermin proof sealed, after completion of cable installation.

6.10 CABLES INSTALLED IN CONCRETE TRENCHES

The cable trench system shall be designed by the Bidder to the approval of the Employer. It shall be complete with removable covers and shall comply with the building and civil works Section.

All cables routed in concrete trenches shall be suitably supported by means of cleats or racks and raised from the trench floor by means of suitable spacers. All cables shall be run in a neat and orderly manner and the crossing of cables within the trench shall not be acceptable without the prior approval of the Employer.

The Bidder shall be responsible for removing and replacing the trench covers free of charge during the execution of his work as directed by the Employer.

6.11 CABLES SUPPORTED ON RACKS, TRAYS AND LADDERS.

6.11.1 General

All single core and multicore main power cables shall be installed in cleats or saddles fixed at intervals. Multicore power cables shall be installed on trays, racks or ladders but segregated from other cables on the same tray by a space of 300 mm.

All control cables shall be installed on racks or trays with adequate clamps, cleats or ties to avoid excessive sagging. The Bidder shall include for the preparation and provision of single line cable routing drawings and detailed cable supporting steelwork drawings, necessary to enable the Employer to give his approval for all main and subsidiary routes before installation commences.

Ample allowance shall be made in the design for additional cabling for future extensions.

Racks and trays shall be secured to channel or similar inserts installed in accordance with Building and Civil works section.

All cables shall be run with a particular regard to neatness of appearance. Multiple runs shall be arranged so that cables entering or leaving the run do so in a logical manner.

Trays and supporting steelwork shall be securely bonded and grounded to the main earthing/grounding system. Bonding and grounding connections shall be adequate to carry prospective fault currents without exceeding thermal or voltage limits.

6.11.2 Supporting Steelwork

All supporting steelwork shall be hot dip galvanised after manufacture and shall be to the approval of the Employer.

Steelwork section shall not be less than 50 x 50 x 6 mm for steel channels and 50 x 50 x 5 mm for angles.
On all main cable runs, supporting structures shall be designed and drilled to accommodate additional cable racks or cleats to the extent of 20% of cables installed under the Contract and those required for known future extensions. The spacing between supporting structures shall be not greater than 1m unless otherwise approved by the Employer.

In cases where cables or their supports must be fixed to structural metal work, care shall be taken to avoid eccentric load transfer to beams or other structural metal. Also, local overloading or deformation of structures shall be avoided. The Bidder shall, if required, demonstrate that the loading resulting from the attachment of cabling steelwork has been taken into account in the steelwork design.

6.11.3 Cable Clamps, Cleats, Saddles and Ties

For single core cables carrying three phase alternating current, nonmagnetic trefoil cleats shall be used and for other single core and three core cables claw type single or multicore unit cleats shall be used. The cleating arrangements for single core cables shall be adequate to withstand all short circuit forces.

Cable clamps shall be used at any change of direction of cable laying, but at agreed intervals on straight runs cable ties of approved design may be used.

Every nonflexible type cable shall be securely supported at a point not more than 1m from its terminal gland to prevent stressing the termination, and on vertical runs passing through floors, immediately above the floor.

6.11.4 Trays, Racks and Ladders

The Bidder shall provide all necessary trays, racks or ladders which shall be fixed at not more than 1m centres. On all main runs trays, racks or ladders shall be installed to accommodate additional cables to the extent of 50% of those installed under the Contract or known future requirements, which is greater.

Cables shall be installed on trays, in general as follows:

(a) Up to l6mm^2 double layer touching.
(b) 25mm^2 to 70mm^2 single layer touching.
(c) Above 70mm^2 single layer with 25mm (minimum) spacing.

All cable trays shall be perforated.

All trays, racks and ladders shall be galvanised to a thickness not less than 1.6 mm and shall be PVC coated in exposed areas. The erection of steelwork, trays, racks or ladders shall not proceed until the Employer's approval for such has been obtained.

Where cables are run on trays, racks or ladders, they shall be tied to the tray at 1 m intervals using materials approved by the Employer.

The cable tray system shall have minimum of 50% of those installed under the Contract or known future requirements, which is greater spare cable capacity throughout.

6.12 TERMINATIONS

6.12.1 General

The Bidder shall be responsible for making all terminations, checking and settingtowork the completed installation. All cables provided as part of the Contract shall be terminated at both ends.

For control wiring the cable tails shall be so bound that each wire may be traced back to its associated cable without difficulty. Cores in twisted pairs or groups shall be kept together. Any spare cores shall be numbered and terminated in the spare terminals furthest away from the cable gland. All cables shall be long enough to permit a second termination if necessary at a future date to the remotest termination location in the panel.

Cable glands shall be used at all equipment to support the weight of cable from the terminations and to seal the cable to the equipment, unless otherwise approved by the

Employer.

PVC, XLPE, silicone rubber and PTFE insulated cables shall be terminated via glands to BS 6121. Glands where water may impinge on cables shall be type ElU, with inner and outer seals and armour clamp. Unarmoured single core cables in these areas shall have type A2 glands.

Glands in indoor locations with the exceptions as noted above shall be type C for armoured cables and type A2 for unarmoured single core cables.

PVC shrouds shall be supplied and installed over each gland.

6.12.2 Power Cables

The Bidder shall ensure that the correct phase rotation and connections are achieved. Particular care shall be taken in the case of heavy cables, where subsequent correction may be difficult. Phase tests will be witnessed by the Employer and, if found necessary, the Bidder shall carry out the reversal of phase connections. Connections to electric motors shall be made as specified. Where motors have tails rather than bushings, a heat shrink or equivalent PVC tube for insulation of the crimp joint shall be provided.

Where insulated glands are provided, the Bidder shall ensure that the insulation is maintained after jointing the cable and shall, if required, demonstrate this to the satisfaction of the Employer.
The tails of two or three or four core cables in air insulated terminations shall be identified by a band of approved tape of appropriate colour over the selfsealing tape.

Single core cables shall be similarly identified by coloured tape over the cable beneath the gland.

6.12.3 Mineral Insulated Cables

The MICS cables shall be terminated with pot type seals in Universal ring type glands utilising cold plastic compound of an approved type. Accessories and methods of anchoring the extension sleeving shall be to the approval of the Employer. All MICS cable terminations shall be complete with high temperature neoprene sleeves of sufficient length over conductors and sundries. All MICS seals shall be tested not less than twentyfour hours after completion with a 1000V insulation resistance tester and a reading of greater than 10 Mohms must be obtained before conductors are connected at any apparatus.

The Bidder shall provide the necessary compound of approved grade and necessary MICS cable glands. Where the ambient temperature is expected to exceed 50ºC, special seals shall be used, details of which shall be approved by the Employer.

6.13 TERMINATING AND JOINTING CONDUCTORS

Compression (indentation) type cable lugs and ferrules shall be provided and all

necessary tools, including dies and other materials for making compression joints, shall be provided by the Bidder, who shall comply with the recommendations of the supplier of cables and lugs in the preparation and execution of each termination.

For stud type terminals approved crimping lugs shall be used.

Where clamp type terminals are used, the conductor shall be terminated without lugs with the exception of flexible conductors having wires 0.3mm or smaller which shall be fitted with crimps. Not more than one conductor shall be terminated in each clamp.

6.14 CORE IDENTIFICATION

A uniform core identification system shall be used throughout the Station. The following clauses outline the broad requirements but the exact implementation shall be agreed with the Employer.

Approved numbered ferrules shall be supplied and fitted to every cable core of control and instrument cables at each termination. The ferrules or sleeves shall be of interlocking ring insulating materials such as plastic which shall be black engraved on yellow background and have a glossy finish. The ferrules or sleeves shall be unaffected by oil or damp. Identification marks on self - sticking cloth shall not be used. The ferrules shall be of “O” or “D” cross section. Ferrules of “C” type cross section shall not be used.

Single d.c. wires shall be identified by a red or blue coloured ring (positive or negative polarity) followed by the identification of the polarity concerned (instrumentation, klaxon, alarm, etc.).

Direct a.c. circuits shall be identified by a yellow end piece followed by an identification of the phase concerned.
Wiring for secondary circuits of voltage transformers shall be identified by a grey end piece and wires in current transformer secondary circuits shall be identified by a green end piece. This identification shall be completed by a terminal index.

All markings for terminal blocks, cables, cable conductors and wiring shall be located on the corresponding fault finding drawing.

Characters suitably marked 'TRIP' in white shall be fitted on all wires associated with trip circuits.

A common system of ferrule numbering shall be adopted such that ferrule numbers at terminations shall agree with ferrule numbers on the internal wiring of equipment.

6.15 CABLE IDENTIFICATION AND SCHEDULES

The Bidder shall prepare and submit computerised cable schedules, the content and style of which shall be to the general approval of the Employer. These shall include cable identification numbers for all cables except those provided for lighting and small power circuits and those which are connected to the load side of distribution boards

for lighting and small power circuits.

The cable identification number system shall be such as to give a brief general indication of the type and function of individual cables and shall be approved by the Employer.

The Bidder may use a fully computerised system for rating, and routing of cables, but shall provide a system that readily permits the cables to be scheduled on the following basis in sequence of cable identification number:

(a) By cable identification number only
(b) By type and size of cables
(c) By function of cable
(d) By main LV ac and DC. Switchboard, actuator boards.
(e) By agreed electrical and mechanical plant functional groups.

The Bidder shall provide copies of the cable schedule in an excel approved format. Cable schedule shall be submitted along with cable trench drawing.

In addition at agreed intervals the Bidder shall provide selected copies of the above schedules in a computer printout form.

Each end of every cable, except those provided for lighting and small power circuits and which are connected to the load sides of distribution fuse boards, shall be identified with a separate cable reference number fitted in a suitable position under the cable termination.

Where cables enter and leave ducts or pipes, suitable identification markers shall be fitted.

The materials of the markers and fastenings shall be such as to avoid corrosion or deterioration due to incompatibility of materials and shall ensure permanent legibility.

6.16 INSPECTION AND TESTING

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 7

EARTHING SYSTEMS, ELECTRODES CONNECTIONS

SECTION 7

EARTHING SYSTEMS, ELECTRODES CONNECTIONS

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SECTION 7

EARTHING SYSTEMS, ELECTRODES CONNECTIONS

7.1 SCOPE

These clauses describe the General Requirements for the Earthing and Lightning Protection and shall be read in conjunction with the Project Requirements and Schedules.

7.2 REFERENCES

7.2.1 American Standards

ANSI/IEEE/std80 IEEE Guide for Safety in AC Substation Grounding
ANSI/IEEE/std81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grounding System

7.2.2 German Standards

DIN VDE 0141 Earthing Systems for Power Installations with Rated Voltages above 1 kV

7.2.3 British Standards

BS 1432 Specification for copper for electrical purposes: high conductivity copper rectangular conductors withdrawn or rolled edges.
BS 1433 Specification for copper for electrical purposes. Rod and bars
BS 2871 Specification for copper and copper alloys. Tubes
BS 2874 Specification for copper and copper alloy rods and sections (other than forging stock).
BS 4360 Specification for weldable structural steel
BS 6360: Specification for conductors in insulated cables and cords.
BS 6651 Protection of Structures against Lightning
BS 6746 Specification for PVC insulation and sheath of electric cables.
BS 7430 Code of Practice for Earthing

7.2.4 International Standards

ISO 427 Wrought copper-tin-alloys - chemical composition and form of wrought productions.
ISO 428 Wrought copper-aluminium alloys - chemical composition and forms of wrought production.
ISO 1187 Special wrought copper alloys - chemical composition and forms of wrought products.
ISO 1137 Wrought coppers (having minimum copper contents of 99.85%) - chemical composition and forms of wrought products.

7.3 GENERAL

An earthing system generally in accordance with the requirements of IEEE 80 and BS

7430 shall be designed under this Contract. Installation and the supply of all materials and equipment shall also be included. The earthing system shall include earth electrodes to provide the connection to the general body of the earth and all conductors and connections to all electrical equipment and metallic structures on the site. The earth electrodes shall limit the potential rise under fault conditions and buried conductors shall be provided to limit potential differences on the site and adjacent to the site to ensure safety to people and animals.

Protection for all electrical equipment against lightning shall also be provided.

7.4 EXTENT OF WORK

The Work under this Section comprises the design, supply and installation including excavation, backfilling and site testing of earthing systems and connections to electrical apparatus at substation. Also included is the lightning protection scheme and the provision
of supply of portable earthing devices.

The Contractor shall be required to undertake all necessary earth resistivity tests at the substation sites and, from these tests, to undertake the design of the earthing systems. These designs, as well as providing safe passage to earth for the stated earth fault currents, shall also include calculation of step, touch and mesh potentials, which shall be within the allowable limits of the standards quoted in this specification.

The design calculations of step, touch and mesh potentials, accompanied by full installation drawings and material requirement schedules, shall be submitted to, and receive the approval of, the Engineer before materials procurement or installation commences.

7.5 SOIL SURVEY

Not later than one month after the site has been handed over for access, the Contractor shall carry out an earth resistivity survey of the sites and report in writing to the Engineer in accordance with the approved programme. The report shall detail the methods and instruments used and the results of the surveys. Based on the results the Contractor shall include in the report his proposals for the resistivities to be used in the design of the earthing system.

The surveys shall show the variation of resistivity across the site and with the depth below the site. The Contractor shall consider if there is a need to model the resistivity in two layers and if there is any advantage in the use of deep rod electrodes.

The surveys shall also determine the depth and nature of any underlying rock, which may limit the depth for driving earth rods or if boring will be necessary for installing earth rods.

The weather conditions prior to and at the time of the surveys shall be recorded in the report and an assessment made of the seasonal variations in resistivity based on

meteorological data for the area. The programme for the project should, as far as possible, time the resistivity surveys to take place during a dry season.

The report should also state if there are any indications that the ground is corrosive to bare copper.

The report shall be approved by the Engineer before proceeding with the design of the earthing system.

7.6 FAULT CURRENT AND DURATION

Each site shall be provided with an earth grid of buried conductors designed for an earth fault current as specified in the section 1 of this specification. The preliminary earthing design shall be such that the potential rise shall not exceed 5 kV.

7.7. EARTH ELECTRODE SYSTEM DESIGN

7.7.1 Design Calculations

The design of the earth electrode systems shall be based on the approved earth resistivity data and the system fault currents and their duration.

The design calculations shall be to the approval of the Engineer and shall be based on the methods given in the standards listed. The calculations shall include the following parameters:

(a) earth resistance of the whole system and of its components
(b) earth potential rise
(c) step, touch and mesh potentials inside and outside the perimeter fence
(d) requirements for a high resistance surface layer
(e) conductor ratings

Earthing points shall be provided such that the combined resistance of the earth grid and all other earthing points does not exceed 0.5 ohm during the dry season.

The earth potential rises shall not exceed the CCITT limits appropriate to the classification of the system unless special precautions are taken to cater for transferred potentials.

Step, touch and mesh potentials shall be within the permitted limits calculated in accordance with the standards given in IEEE 80 for the proposed surface layer.

For calculating the conductor size of main mesh a current distribution of 30%-70% may be considered, In case direct current is allowed to pass through mat in any mode of operation, allowance for the same shall be made in design.

For Designing the Earthing Grid, software solution must be adopted. Hand calculation for substation having 132kV Voltage level & above (AIS & GIS) shall not be

acceptable. The Contractor shall always consider multi-layer soil model for such calculation. Single layer soil model is generally not acceptable. Employer owns Eaton's CYMGRD version 8.0 software which shall be deemed to be used by the prospective Contractors for such Design calculation. Contractor shall share Soft copy files of the software and seek review and approval from the Employer.

7.7.2 Earth Electrode

The earth electrode shall comprise a system of bare conductors forming a mesh buried near the surface of the ground and supplemented, if required, by one or more of the following electrodes:

(a) a system of interconnected rods driven into the ground
(b) a mesh system of bare conductors buried in the ground
(c) structural metalwork in direct contact with the ground
(d) reinforcing steel in buried concrete
(e) a system of bare conductors buried near the surface of the ground outside the perimeter fence

7.7.3 Mesh System

The mesh system shall be designed in accordance with subclause 7.7.1 above to limit touch, step and mesh potentials taking into account the combined length of the mesh conductors, other buried conductors and rods but excluding any buried conductors outside the perimeter fence. Due regard shall be given to nonlinear distribution of the fault current giving rise to the highest potentials at mesh corners.

The rating of the mesh conductors shall be compatible with the fault currents after allowing for parallel paths of hard drawn high conductivity copper strip with a minimum conductor size of 150 mm^2.

The conductor shall be installed in trenches excavated by the Contractor to a depth of 500mm. The system will be installed after all foundations have been laid and the site filled to 100mm below finished level. When the earthing grid has been laid and backfilled, bricks will be laid up to finished site level. Where the excavated material is rocky or may be difficult to consolidate, the backfilling shall be carried out using other material to the approval of the Engineer. The cost of such material shall be deemed to be included in the Contract.

7.7.4 Interconnected Rods

If the design calculations show that a mesh alone is unable to limit the potentials to the required values, then the mesh shall be supplemented by the use of interconnected earthing rods driven into the ground or installed in bored holes.

Rods shall be installed inside the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. (The spacing between rods shall not be less than their length, unless rating considerations determine otherwise). The copper rod electrodes of 15mm diameter shall be interconnected in groups of four

to eight rods by insulated copper conductors and non-ferrous clamps to form a ring. Each group shall be connected to the mesh by duplicate insulated copper conductor via disconnecting test links.

Individual rods may be connected directly to the mesh, provided the rod can be disconnected for testing.

Rods installed in bored holes may be used to reach lower resistivity ground strata at depths beyond the reach of driven rods or where rock is encountered and it is not possible to drive rods. After installing the rod, the bored hole shall be backfilled with a low resistivity liquid mixture, which shall not shrink after pouring, to ensure good contact between the rod and the ground for the life of the installation.

The resistance and rating of individual rods and the combined resistance of the groups of rods in the proposed design shall be calculated and the rating of the interconnecting conductors shall not be less than that of the group of rods with a minimum conductor size of 70 mm^2.

The calculation of potentials in the design of the complete installation shall be made without the group of rods with the lowest estimated resistance to simulate the condition with the group disconnected for testing.

7.7.5 Other Conductors

As an alternative to rods to supplement a mesh, additional bare copper conductors with a crosssection area of not less than 150 mm^2 may be used. They shall be buried in the ground within the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. Such conductors may be laid below the mesh, below foundations or in areas where there is no plant. It shall be shown by calculation that the step potentials are low in such areas.

The conductor shall be in a ring, or a part of a ring, with at least two widely separated connections to the mesh or other parts of the earthing system.

7.7.6 Reinforcing Steel

The reinforcing steel in the foundations of buildings containing the primary electrical equipment may be used as auxiliary electrodes, subject to the approval of the Engineer. The Contractor shall show in the design calculations that the fault currents and D.C. stray currents will not damage the structure.

Steel reinforcing mesh in the floors of the building may also be used for the control of step and touch potentials within the building, subject to the approval of the Engineer.

7.7.7 Conductors Outside Perimeter Fence

If the design calculations show that the step and touch potentials outside the perimeter fence or wall exceed the limits, then additional bare conductors shall be buried in the ground outside the fence in the form of rings encircling the whole site.

The distance of the conductors from the fence and the depth shall be determined in the design to ensure that step and touch potentials are within the limits.

The minimum conductor size shall be 75 mm^2 copper and shall be connected to the fence or the mesh with 75 mm^2 conductors at each corner of the site and at intervals of not more than 100 m. These conductors shall not be included in the calculations called for above.

7.8 DESIGN OF EARTH SYSTEM

7.8.1 Earth System

An earth system shall comprise the following components:

(a) the conductors between the earth electrode system and the main earth bar
(b) the main earth bar
(c) the conductors between the main earth bar and the metallic frames, enclosures or supports of electrical equipment
(d) the conductors between structural metalwork and nonelectrical equipment and the main earth bar

The rating of earth system conductors connected between an item of electrical plant and the earth electrode system shall be sufficient to withstand the fault currents and duration, after allowing for the parallel paths through the earth system conductors, with any one conductor disconnected.

The design of earth system shall take into account the corrosiveness of the soil based on the soil survey.

The design comprising all the above mentioned items shall be submitted to the Engineer for approval within four months of the award of Contract.

7.8.2 Connection of System Neutrals and Earth

The system neutral points within a substation shall have duplicate connections to the closest link chamber of an earthing point.

The Transformer Neutrals shall be directly Buried to earth upto 15 meter minimum. The connection shall be in delta format. In addition to transformer neutrals, the contractor shall consider direct earthing of all LA neutrals, Lightning mast neutrals to ground through earthing rod (15 meter minimum).

The earth electrodes of a neutral earthing point shall be arranged in two groups with a conductor from each group to a test link and there shall be duplicate bare copper conductors of cross sectional area not less than 150 mm^2 from each test link to the earth grid. The duplicate connection may be in the form of a ring.

Neutral earthing connections between the substation system (transformer) neutral and

the test links shall be of bare copper tape, secured and supported on stand-off insulators so that there is no contact between copper tape and transformer tank.

Neutral earthing conductors shall normally be buried directly in the ground but where necessary, they may be cleated to walls, fixed to cable racks or laid in the cable trenches.

7.8.3 Main Earth Bar

The main earth bar shall be in the form of a ring or rings of bare conductors surrounding, or within, an area in which items to be earthed are located. Where two or more rings are installed, they shall be interconnected by at least two conductors which shall be widely separated.

The main earth bar, or parts thereof, may also form part of the earth electrode system, providing this is bare conductor.
Each main earth bar shall be connected by at least two widely separated conductors to the earth electrode system.

The minimum conductor size for the main earth and interconnections between earth bars and the earth electrode system shall not be less than 150 mm^2.

7.8.4 Electrical Equipment Tank and Structure Connections to Earth

Connections between: (a) all HV electrical equipment and (b) LV electrical equipment comprising substantial multicubicle switchboards and the main earth bar shall be duplicated. The bare copper conductor size shall have a minimum cross section area of 150 mm^2.

All substation equipment, including disconnectors, earth switches, main transformer tanks, current and voltage transformer tanks, switchgear and electrical supporting steelwork, etc. shall all be connected with the earth grid.

Surge arresters installed for the protection of transformers shall be connected by low reactance paths both to the transformer tanks and to the earth grid.

An earth mat shall be installed at all operating positions for outdoor HV equipment manual operating mechanism boxes and local electrical control cubicles to ensure the safety of the operator. The mat shall be directly bonded to the cubicle and the conductors forming the mat and the bonding connection shall have a minimum copper crosssection area of 75 mm^2.

Galvanized structures comprising bolted lattice components shall not be used as the sole earth connection path to post and strain insulators.

Buildings containing electrical equipment shall be provided, at each level, with a ring of earthing conductors which shall have duplicate connections to the earth grid outside the building. The frames of all switchgears, control and relay panels and other electrical equipment and exposed structural metal work shall be connected by

branches to a ring. The ring and branch conductors shall be of the same material as the earth grid. Strip run within buildings, inside cable trenches or above ground level on apparatus shall be neatly supported in non-ferrous clamps.

Connections between other LV electrical equipment and the earth bar need not be duplicated. The single conductor shall be rated to withstand the fault rating of the equipment.

7.8.5 Connections to NonElectrical Structural Metalwork and Equipment

All metalwork within the project area which does not form part of the electrical equipment shall be bonded to the main earth bar except where otherwise specified. The bonding conductor size shall be not less than 150 mm^2.

Individual components of metallic structures of plant shall be bonded to adjacent components to form an electrically continuous metallic path to the bonding conductor.

Small electrically isolated metallic components mounted on nonconducting building fabric need not be bonded to the main earth bar.

7.9 MATERIALS AND INSTALLATION

The GTP of Earthing material along with wits technical parameters as used in the design and the methodology of earthing system installation shall be submitted for approval.

7.9.1 Earthing Conductors

Conductors shall be of high conductivity copper in the form of circular conductors stranded to IEC 60228 or solid rods or bars to BS1433.

Conductor sheaths shall be of PVC to meet the requirements of BS 6746 Grade TM1 or IEC 60502 Grade ST1 with a minimum thickness of 1.5 mm.

Buried conductors which are not part of the earth electrode system shall be PVC sheathed circular stranded cable.

Bare strip conductors only shall be used for earth electrodes or voltage control meshes.

Conductors buried in the ground shall normally be laid at a depth of 500 mm in an excavated trench. The backfill in the vicinity of the conductor shall be free of stones and the whole backfill shall be well consolidated. Conductors not forming part of a voltage control mesh shall be laid at the depth required by the approved design and, in the case of PVC sheathed conductor, at the same depth as any auxiliary power or control cables following the same route.

All conductors not buried in the ground shall be straightened immediately prior to installation and supported clear of the adjacent surface.

7.9.2 Earth Rods

Earth rods shall be driven to a depth below the ground water table level, to be determined by the Contractor during soil investigation and survey of site.

The earth rods shall be of harddrawn high conductivity copper with a diameter of not less than 15 mm with hardened steel driving caps and tips. The rods should be as long as possible but couplings may be used to obtain the overall depth of driving required by the design.

The rods shall be installed by driving into the ground with a power hammer of suitable design to ensure the minimum of distortion to the rod. Where it is not possible to drive rods to the full depth required due to the presence of a strata of rock, then holes shall be drilled or blasted in the rock. The holes shall be filled with bentonite or other approved material prior to inserting the rod.
If difficult driving conditions arising from hard or rocky ground are encountered or are anticipated or there is a need for deep rods, then high tensile steel rods shall be used. High tensile steel rods shall have a molecularly bonded high conductivity copper coating with a minimum radial thickness of not less than 0.25 mm. The overall diameter shall be not less than 12 mm. Rolled external screw threads shall be used on the rods for coupling and after rolling the thickness of the copper coating on the threaded portion shall be not less than 0.05 mm.

Rods, driving caps and tips shall abut at couplings to ensure that the couplings and screw threads are not subject to driving forces. All screw threads shall be fully shrouded at the couplings. Alternatively, conical couplings may be used to the approval of the Engineer.

High conductivity copper for earth rods shall have a minimum copper content (including silver) of 99.90% to ISO 1337, CuETP or CuFRHS (BS 2894 Grade C101 or C102) for copper earth rods and to ISO 1337 Grade CuETP (BS 28734 Grade C101) for the molecular bonded copper coating of steel rods.

The steel for copperclad steel rods shall be low carbon steel with a tensile strength of not less than 570 N/mm^2 to ISO 630, Grade Fe 430A (BS 4360, Grade 43A) or better.

Couplings for copper rods shall be of 5% phosphor bronze (coppertinphosphorous) to ISO 427, CU Sn4 (BS 2874, Grade PB 102M) and for copper bonded steel rods of 3% silicon or 7% aluminum bronze to BS 2874, Grade CS 101 and BS 2871, Grade CA 102.

7.9.3 Fittings

Clips for supporting strip conductors not buried in the ground shall be of the direct contact type and clips for circular conductors shall be of the cable saddle type. The clips shall support the conductors clear of the structure.

Conductors shall be connected to earth rods by a bolted clamp to facilitate removal of

the conductor for testing the rod.

Disconnecting links shall comprise a high conductivity copper link supported on two insulators mounted on a galvanised steel base for bolting to the supporting structure. The two conductors shall be in direct contact with the link and shall not be disturbed by the removal of the link. Links for mounting at ground level shall be mounted on bolts embedded in a concrete base.

Disconnecting links mounted at ground level and the connections at the earth rods shall be enclosed in concrete inspection pits, with concrete lids, installed flush with the ground level.

All conductor fittings shall be manufactured from high strength copper alloys with phosphor bronze nuts, bolts, washers and screws. Binary brass copper alloys will not be acceptable. All fittings shall be designed for the specific application and shall not be permanently deformed when correctly installed.

Sheathed conductor support fittings may be of silicon aluminium, glassfilled nylon or other tough nonhygroscopic material for indoor installations.

Fittings not in direct contact with bare or sheathed conductors may be of hot-dip galvanised steel. Bimetallic connectors shall be used between conductors of dissimilar materials and insulating material shall be interposed between metallic fittings and structures of dissimilar materials to prevent corrosion.

7.9.4 Joints

Permanent joints shall be made by exothermic welding below ground, or crimping for above ground connections.

Detachable joints shall be bolted and stranded conductors at bolted joints shall be terminated in exothermically welded lugs or a crimped cable socket. The diameter of any holes drilled in strip conductors shall not be greater than half the width of the strip.

Connections to electrical equipment shall be detachable and made at the earthing studs or bolts provided on the equipment by the manufacturer. When an earthing point is not provided, the point and method of connection shall be agreed with the Engineer.

Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be either by direct exothermic welding or by bolting using a stud welded to the structure. Drilling of a structural member for a directly bolted connection shall only be carried out to the approval of the Engineer.

Bolted joints in metallic structures, including pipework and which do not provide direct metallic contact, shall either be bridged by a bonding conductor or both sides of the joint shall be separately bonded to earth, unless the joint is intended to be an insulated joint for cathodic protection or other purposes.

When the reinforcing in concrete is used as a part of the earthing system, the fittings used to provide a connection point at the surface of the concrete shall be exothermically welded to a reinforcing bar. This fitting shall be provided with a bolted connection for an earthing conductor. The main bars in the reinforcing shall be welded together at intervals to ensure electrical continuity throughout the reinforcing.

No connections shall be made to reinforcing bars and other steelwork which do not form part of the earthing system and are completely encased in concrete.

7.10 EARTHING OF FENCES

7.10.1 Method

Metallic fences shall be separately earthed unless they come within 1.8m of any equipment or structure above the surface of the ground and which is connected to the main earthing system. If the separation of 1.8m cannot be obtained, the fence shall be bonded to the main earthing system.

7.10.2 Separately Earthed Fences

The earthing of a fence shall be provided by connecting certain metallic fence posts to an earth rod by a copper conductor. The earth rod shall be driven adjacent to the posts inside the fence line to a depth of not less than 3.0m. Where no metallic posts are provided, the earth rods shall be connected directly to the metal wires, mesh or other components of the fence.

If, owing to the nature of the ground, it is not possible to drive earth rods, then fence posts shall be connected to the centre point of a 20 m length of bare copper conductor buried in the ground at a depth of 500 mm, running closely parallel to the inside of the fence.

The earth rods or bare conductor electrodes shall be installed at each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

7.10.3 Bonded Fences

Fences which need to be bonded to the main earthing system of the installation shall be connected by copper conductors to the nearest accessible point on the main earthing system at each point where the fence comes within 1.8 m of any electrical equipment. Bonds shall also be made to each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

7.10.4 Bonding of Fence Components

Fences made up of bolted steel or other metallic components do not require bonding between components. Where such fences have nonmetallic components, bonds shall be installed to maintain continuity between metallic components. Reinforced concrete

components shall be treated as being nonmetallic.

Longitudinal wires for supporting other fence components, or for anticlimbing guards and the wires of chain link shall be directly bonded to each fence earth electrode or to each bond to the main earthing system.

Metallic components on masonry, brick, concrete or similar boundary wall shall be treated in the same manner as metallic fences.

Wire fence components coated for anticorrosion protection shall be earthed in accordance with this Clause.

7.10.5 Gates

The fixed metallic components on both sides of the gate shall be directly bonded together by a copper conductor installed under the surface of the access way. Flexible conductors shall be installed to bond the moving parts of the gates to the metallic fixed parts. An earth rod or a bond to the main earthing system shall be installed at each gate.

7.10.6 Potential Control Outside Fences

Where the approved design calculations show that the touch or step potentials outside the fence or boundary wall would otherwise be excessive, bare copper conductors shall be buried in the ground outside the fence or boundary wall at such depths and spacings as are shown in the approved design calculations to give acceptable touch and step potentials. The conductors shall form complete rings surrounding the installation and each ring shall be bonded to the adjacent ring and to the fence at each corner, at each gate and at intervals of not more than 100 m. In this case separate earth electrodes are not required for the fences.

If the boundary fence or wall is substantially nonmetallic, the rings of conductors shall be bonded to the main earth system at each corner of the site and at intervals of not more than 100 m. Any metallic components on such boundary fences or walls shall be bonded to the earthing system in accordance with this Specification.

If the boundary fence is metallic and is not within 1.8 m of any part of the main earthing system or equipment bonded thereto, the fence and outer conductor rings shall not be connected to the main earthing system unless the approved design calculations show otherwise.

Any meshes formed by bonding the outer conductors to the main earthing system shall be subdivided by additional conductors, if required, to give acceptable touch, step and mesh potentials.

7.10.7 Conductors

All conductors used for earthing and bonding the fences and components and for outer rings shall have a crosssectional area of not less than 70 mm^2.

7.11 DIRECT STROKE LIGHTNING PROTECTION

The Contractor shall provide adequate overhead shielding to effectively prevent direct lightning strikes to any equipment or energized bus within the switchyard areas. The system shall also be designed to provide "effective shielding" to ensure that no insulation flashover can result from atmospheric discharges striking the overhead shielding. The screens shall be of aluminium clad steel wires of not less than 50 sq.mm. total section, and connected to provide low impedance paths to earth.

The lightning protection scheme shall be designed by the Contractor using the latest version of the electro geometric model (EGM). Detailed calculations demonstrating the adequacy of the proposed shielding shall be submitted to the Employer for approval prior to the overhead shielding design being finalized.

The Contractor may propose a lightning mast and/or shield wire system, however shielding by shield wires is preferred by the Employer. Overhead shield wires shall not make use of "X" patterns & shall not lead to a fault, if broken. Conductor sag shall be considered when designing the overhead shielding system; however, conductor swing need not be considered.

The overhead earthwire shall be suitable for extension to protect the substation equipment to be installed in future stages of development.

7.12 Portable Earthing Devices

Portable earthing devices for use with outdoor 400KV, 230 kV and 132 kV apparatus in substations shall be supplied in the numbers stated in Schedule A of Requirements and shall comprise:

(a) Copper alloy earth end clamp for connection to the rigid loops in equipment earth bonding connections.
(b) Aluminium alloy line and busbar end clamp to suit the connectors of the type supplied under the Contract. (
c) Flexible stranded aluminium alloy conductor with clear protective PVC sheath, sized suitable for the specified fault level and duration.
(d) Telescopic operating pole of glass fibre or similar material, of sufficient length to reach the height of connections to high voltage equipment from ground, but retractable into a carrying length not exceeding 2.5 m, and complete with non-slip hand grips.
(e) Cable & all the clamps associated with grounding shall be 63KA, 50KA & 40KA with 0.5s for 400KV, 230 kV and 132 kV voltage level respectively.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 8

BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

SECTION 8

BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

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SECTION 8

BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

8.1 SCOPE

These clauses describe the General Technical Requirements for Batteries, Chargers and DC distribution switchgear for use in substations for 110V DC power for switchgear operations, protection, control, alarms, indications and emergency lighting.

The equipment shall be supplied, installed and commissioned as per instruction and approval of the engineers.

8.2 REFERENCES

8.2.1 IEC Standards

IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
IEC 60146	Semiconductor converters
IEC 60146-1-1	Basic requirements of electrical power converters
IEC 60146-1-3	Transformers and reactors
IEC 6060529	Degree of protection provided by enclosures
IEC 60439	Low voltage switchgear and control gear assemblies (BS EN 60439)
IEC 60623	Vented nickel cadmium prismatic rechargeable single cells

8.2.2 British Standards

BS 88	Cartridge fuses for voltages up to and including 1000 VAC and 1500 V DC.
BS 381C	Specification for colours for identification coding and special purposes.
BS 5634	Method of Test for Potassium Hydroxide.
BS 6231	Specification for PVC insulated cables for switchgear and controlgear wiring.

8.3 DESIGN REQUIREMENTS

8.3.1 General

Batteries shall be located in separate mechanically ventilated rooms, which will be provided with sinks and water supplies. Storage facilities will be provided for electrolyte, distilled water and maintenance equipment.

The voltage measured at the main distribution switchgear shall not vary by more than plus 10 percent or minus 20 percent of the nominal voltage under all charging conditions when operating in accordance with the requirements of this Section.

The complete equipment shall preferably be a manufacturer's standard but any departure from this Specification shall be subject to the approval of the Engineer.

8.4 BATTERIES

8.4.1 Type of Battery

The battery shall be of the high performance Nickel Cadmium pocket plate type complying with IEC 60623 and shall be designed for a life expectancy of 25 years.

Battery cases shall be of high impact translucent plastic or annealed glass and shall be indelibly marked with maximum and minimum electrolyte levels. The design of the battery shall permit the free discharge of the gases produced during the normal operating cycle, whilst excluding dust. Spray arresters shall be included.

The electrolyte shall be free from impurities and the Potassium Hydroxide used shall comply with BS 5634. Dilution of the alkaline electrolyte and topping up of cells shall be carried out using distilled water only.

A complete set of test and maintenance accessories, suitably boxed, shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Cells shall be permanently marked with the following information:

Manufacturer's reference number and code
Year and month of manufacture
Voltage and nominal capacity at the 5 hour discharge rate

The electrolyte capacity and general design of the cells shall be such that inspection and maintenance, including topping up of the electrolyte, shall be at intervals of not less than twelve months.

8.4.2 Initial Charge and Test Discharge

The initial charge, test discharge and subsequent recharge of the battery must be carried out under continuous supervision. Resistors, instruments, leads, and the other apparatus will be necessary for the initial charge, test discharge and subsequent recharge of the battery.

8.4.3 Battery Duty

The battery shall have sufficient capacity to supply the following continuous and intermittent loads for the periods specified, with the chargers out of service.

The battery shall supply Standing DC load for protection, control, indications and alarms for 5 hours. This loading shall be determined from all equipment to be supplied

on this Contract. In addition the future circuit requirements estimated on the same basis as the present requirements.

At the end of 5 hours the battery shall have sufficient capacity to complete the operations listed below, at the end of which duty the system voltage shall not have dropped below 90 percent of the nominal voltage with the standing loads, specified above, connected.

1. Two closing operations on all circuit breakers (including future) supplied by the battery.

2. Two tripping operations on all circuit breakers (including future) supplied by the battery. Where busbar protection is provided, it shall be assumed that all circuit breakers in any one busbar protection zone trip simultaneously.

3. Charging of DC motor wound circuit breaker closing springs (where applicable) to enable the closing operations to be carried out.

4. At the end of these duties, the battery voltage shall not have dropped such that the voltage at the battery terminals falls below 90% of the nominal system voltage when supplying the standing load.

5. In addition, the voltages at the terminals of all components in the system (eg. relays, trip and closing coils) shall not be outside of the individual voltage limits applying to them.

6. A margin of 10 % shall be allowed for derating of this battery over its life time.

All quantities derived in this manner shall be quoted in the Tender, but shall not be used for ordering materials until specifically approved by the Engineer. Detailed calculations, and loading characteristics on which these are based, shall be submitted to the Engineer for approval at an early stage of the execution of the project.

8.4.4 Location of Batteries

The batteries shall be housed in a ventilated battery room. The charging equipment and distribution switchboards shall be housed in a separate room.
The floor of the battery room shall be coated with a suitable electrolyte resistant protective coating. The floor shall be fitted with a drain and shall have sufficient slope to prevent any major electrolyte spillages from entering into other areas.

No ducts or any other items shall penetrate the floor or create a means whereby spillage can drain away apart from the drain provided for this purpose.

The ventilation fans and lamps in battery room shall be an explosion proof type.

8.4.5 Battery mounting connections and accessories

Batteries shall be placed on timber boards mounted in double tiers on steel stands of robust construction and treated with acid resisting enamel or gloss paint to BS 381C

No.361. The cells shall be arranged so that each cell is readily accessible for inspection and maintenance and it shall be possible to remove any one cell without disturbing the remaining cells. The stands shall be mounted on insulators and be so dimensioned that the bottom of the lower tier is not less than 300mm above the floor.

Alternatively, batteries may be mounted in a similar manner on treated hardwood stands.

Batteries shall be supplied and erected complete with all necessary connections and cabling. Connections between tiers, between end cells and between porcelain wall bushings shall be by PVC cables arranged on suitable racking or supports. Before jointing, joint faces shall be bright metal, free from dirt, and shall be protected by a coating of petroleum jelly. Terminal and intercell connections shall be of high conductivity corrosion free material.

Cartridge fuses shall be provided in both positive and negative leads, positioned as close to the battery as possible and shall be rated for at least three times the maximum battery discharge current at the highest operating voltage. The two fuses shall be mounted on opposite ends of the battery stand or rack in an approved manner. These fuse links shall comply with BS 88 Clause DC. 40 and shall be bolted in position without carriers.

Warning labels shall be fitted to warn personnel of the danger of removing or replacing a fuse whilst the load is connected and that fuses should not be removed immediately following boost charge due to the possible ignition of hydrogen gas.

Fuses between the battery and charger shall be located adjacent to the battery in a similar manner to that described above. A warning label shall be placed on the charging equipment indicating the location of these fuses and the fact that they should be removed to isolate the charger from the battery.

It shall not be possible to leave the battery disconnected (by means of switches or removal or operation of fuses) without some local and remote indication that such a state exists.

One set of miscellaneous equipment, including two syringe hydrometers, one celltesting voltmeter, two cellbridging connectors, two electrolytepouring funnels, two electrolyte thermometers, battery instruction card for wall mounting, electrolyte airtight containers, labels, tools and other items necessary for the erection and correct functioning and maintenance of the equipment, shall be provided for each station.

8.5 CONTROL AND CHARGING EQUIPMENT

Each battery charging equipment shall comply with the requirements of BS 4417 (IEC 146), shall be of the thyristor controlled automatic constant voltage type with current limit facilities and shall be suitable for supplying the normal constant load, at the same time maintaining the battery to which it is connected in a fully charged condition. Generally, all equipment shall be naturally ventilated; however, forced Cooling shall be provided when required, specially to, main transformer, rectifier module etc.

All the equipment for each charger shall be contained in a separate ventilated steel

cubicle. The charger cubicles shall normally be mounted immediately adjacent to the DC distribution panel to form a board and shall be of matching design colour and appearance.

Where their ratings permit, chargers shall preferably be designed for operation from a single phase AC auxiliary supply with a nominal voltage of 230 V. Otherwise a three phase 400V supply may be utilized. Chargers shall maintain the float charge automatically for all DC loads between 0 and 100%, irrespective of variations in the voltage of the ac supply within the following limits :

Frequency variation : 47 to 51 Hz.
Voltage variation : ± 15%

The mains transformer shall be of a suitable rating and design. Clearly marked offcircuit tappings shall be provided on the primary windings and change of tapping shall be by means of easily accessible links. The transformer shall be of the natural aircooled type capable of operating continuously at full load on any tapping with the maximum specified ambient temperature.

All rectifiers and semiconducting devices employed in the charger shall be of the silicon type. They shall be adequately rated, with due regard to air temperature within the charger enclosure, for the maximum ambient temperature.

The rating of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate for the battery.

Each charger shall also incorporate a boost charge feature which shall, after having been started, provide an automatically controlled high charge rate sufficient to restore a fully discharged battery to the fully charged state within the shortest possible time without excessive gassing or any form of damage to the battery. The boost charge shall be initiated manually or automatically upon detection of a significant battery discharge. An adjustable timer shall be provided to automatically switch the charger to the float condition after the correct recharge period. Load shall be kept connected to the charger during boast charge.

Should the AC supply fail while a battery is on boost charge, the switching arrangements shall automatically revert the charger to float charge status .

The output voltage regulator shall be adjustable for both float and boost charge modes, within limits approved by the Engineer, by means of clearly marked controls located inside the cubicle.
Although it is not intended that the charger be operated with the battery disconnected, the design of the charger shall be such that with the battery disconnected the charger will maintain the system voltage without any damage to itself and with a ripple voltage no greater than 2.0% rms of the nominal output voltage.

The charger shall automatically adjust the charging current from a maximum value not less than the battery capacity divided by 5 hours to a minimum value of not more than the battery capacity divided by 200 hours. The charger shall automatically adjust the

charging current from Boost to float charging current when required. The charging circuitry shall be so designed that the failure of any component will not give a situation which will cause permanent damage to the battery by over charging.

Each charger shall have a float charge maximum current rating sufficient to meet the total standing load current on the dc distribution board plus a battery charging current equal numerically to 1-2mA of the battery capacity at the 5 hour rate. However, the battery manufacturer recommendation shall always be preferred in this case.

Each charger shall be designed with a performance on float charge such that with the output voltage set at approximately 1.45 V per cell at 50% load and rated input voltage & frequency, the output voltage shall not vary by more than plus 3% to minus 2% with any combination of input supply voltage and frequency variation as stipulated in this Specification and output current variation from 0100% of rating.

Each charger shall be suitable for operating alone or in parallel with the other charger. When operating with both chargers, one charger shall be arranged to supply the standing load with the second charger in the quiescent standby mode.

Each charger shall also have a taper characteristic boost charging facility which shall be selectable by a float/boost charge selection switch and which will give boost charging of 1.60 1.75 volts per cell.

Each charger shall be designed with a performance on boost charge such that with rated input voltage and frequency the charger output shall not be less than its rating in Watts at 1.3 V and 1.65 V per cell, and also the output voltage shall be 1.60 1.75 V per cell over an output range of 0 100% of rating.

The boost charging equipment shall be capable of recharging the battery within six hours following a one hour discharge period.

In the event of the battery becoming discharged during an AC supply failure, the rate at which recharging commences shall be as high as possible consistent with maintaining the automatic charging constant voltage feature and with the connections remaining undisturbed as for normal service.

The charger shall have an automatic boost/quick charge feature, which shall operate upon detection of a significant battery discharge. When, after a mains failure, the AC supply voltage returns and the battery have been significantly discharged, the charger will operate in current limit. If the current limit lasts for more than a specified time and the charging current does not fall back to float level, the automatic high rate/Boost charge shall be activated.

An override selector switch shall be provided inside the charger unit to enable a first conditioning charge to be made, in line with the battery manufacturer’s recommendations, for batteries which are shipped dry and require forming at site.

A voltage dropper diode unit (typically called DVR module) shall be incorporated in the output circuit of each charger to limit the load voltage during boost charging of the

battery. These diodes shall be continuously rated to carry the maximum possible load current during boost charging. The diode unit shall not be in service in the normal float charging mode. Should the voltage stabilizer/ DVR unit fail in the boost charging mode, the charger shall automatically revert to the float mode.

An anti-paralleling diode shall be provided in each positive feed to the DC distribution board to prevent faults on one supply affecting the other. These diodes shall be continuously rated to carry the maximum possible discharge current likely to occur in service and a safety factor of 4 shall be used to determine the repetitive peak reverse voltage rating. The I^2t, i.e. energy handling capacity for short time, rating of the diodes shall be such that in the event of a DC short circuit, no damage to the diodes shall result.

Each charger shall be capable of sustaining, without damage to itself, a continuous permanent short circuit across its output terminals. The use of fuses, MCBs or other similar devices will not be acceptable in meeting this requirement.

Suitable relays shall be provided for each charger to detect failure of the incoming supply and failure of the DC output when in float charge mode. These relays shall operate appropriate indicating lamps on the respective charger front panel and shall have additional voltage free contacts for operating remote and supervisory alarms. These alarms shall be immune from normal supply fluctuations and shall not be initiated when any one charger is taken out of service.

The charger shall also be fitted with a device to deenergise the charger in the event of a DC output float over voltage.

Each charger shall be provided, as a minimum, with the following instrumentation, indication and alarm facilities:

Indicating lamps for the AC supply to the rectifier and DC supply from the rectifier.
Indicating lamps for float and boost charging operations.
Voltmeter Input voltage.
Voltmeter Output voltage.
Ammeter Output current.
Alarm Charger failure.
Alarm – Charger Main transformer failure.
Alarm – Charger Rectifier Diode Module failure.
Alarm – Charger DVR module failure.
Alarm Mains failure.

The following battery alarms shall also be provided:

Battery fuse failure
Diode assembly failure
Battery circuit faulty
Low DC volts
High AC volts

Earth fault +ve
Earth fault -ve

Lamp test facilities shall be included.
A “charger faulty” alarm for each charger and a “battery faulty” alarm shall be provided in the substation control room and to the SCADA system where applicable.

Each battery charger shall be equipped with charge fail detection equipment to give local indication and remote alarm if the voltage from the charger falls below a preset level which will be lower than the nominal float charge voltage. Suitable blocking diodes shall be provided to prevent the battery voltage being supplied to the equipment and so prevent charge fail detection.

The device shall not operate on switching surges or transient loss of voltage due to faults on the AC system. The voltage at which the alarm operates shall be adjustable for operation over a range to be approved by the Engineer.

Each charger shall be equipped with a switchfuse for the incoming AC supply and an off load isolator for the DC output.

Bidders shall include particulars with their tender on the method of adjustment included to compensate for ageing rectifier elements. The construction of the charger shall be such that access to all components is readily available for maintenance removal or replacement. Internal panels used for mounting equipment shall be on swing frames to allow for access to the charger interior.

8.6 DISTRIBUTION SWITCHBOARDS

The switchboard shall comply with the requirements of BS 5468 (IEC 60439)

The distribution switchboard shall be of the cubicle type or otherwise incorporated in the cubicles for battery chargers. placed separate from battery charger. Double pole switches and fuses or switch fuses (miniature circuit breakers to BS 4752 or IEC 60127 may only be used if it can be shown that there will be no discrimination problems with sub-circuits) shall be fitted to the DC switchboard as required by substation services but, as a minimum requirement, that set out in the Schedule A of Requirements.

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of cubicle type control panels. No equipment associated with the chargers shall be installed in the distribution board.

Distribution panels shall incorporate doublepole switches and fuses for each of the outgoing DC circuits and doublepole isolators for the incoming DC supplies. The panel shall be provided with a voltmeter and centre zero ammeter on each incoming circuit.

A switching device, MCB/MCCB or contactor shall be provided for the purpose of sectionalising the busbar.

A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the distribution panel.

A low voltage detecting device for the system shall be incorporated in the distribution panel. Novolt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.
In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage detecting devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

Connections between the battery and the distribution cubicle shall be made in PVC insulated cable as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring, be sheathed overall and be cleated to walls as required.

Cable boxes or glands shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with an earthing bar of hard drawn high conductivity copper which shall be sized to carry the prospective earth fault current without damage or danger.

Each distribution board shall be provided with a suitable plug and socket assembly (socket
to be provided loose) to allow the connection of an external battery packs to allow support of the load in the case of a battery or charger fault.

The cubicles for the chargers and distribution boards shall be of rigid, formed sheet metal construction, insect and vermin proof, having front facing doors allowing maximum access to the working parts, when open. The design of the cubicles for the chargers shall be such as to prevent the ingress of dust and minimise the spread of flames or ionised zones, shall be to IEC 60529 IP52, but at the same time shall provide all necessary ventilation and cooling. The design of the frames shall allow the clamping and holding of all chokes, transformers and similar sources of vibration, so that vibration will be minimised, satisfy relevant standards, and not limit the life of the equipment. The frame shall allow the fixing of lifting and so that the equipment remains properly mechanically supported whilst being transported, lifted and installed.

8.7 LABELLING

All relays, instruments and control devices, and each unit of the equipment, shall be provided with a label. All labels and lettering shall be of sufficient size to provide easy reading from the normal operating or maintenance positions and shall consist of black lettering on a white background. All warning and danger labels shall have white

lettering on a red background. Labels shall be of the non-corrodible type and lettering shall be of motorway script or similar. If plastic labels are used, these shall be laminated to avoid warping.

8.8 SPECIAL TOOLS

The Bidder shall provide a complete set of all special tools and services necessary for the erection and maintenance of the complete equipment.

8.9 INSPECTION AND TESTING

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 9

LVAC DISTRIBUTION SYSTEM & SWITCHGEAR

SECTION 9

LVAC DISTRIBUTION SYSTEM & SWITCHGEAR

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SECTION 9

LVAC DISTRIBUTION SYSTEM & SWITCHGEAR

9.1 SCOPE and LVAC System Design

These clauses describe the General Technical Requirements for LVAC system and switch boards for supplies to “Substation Services” including lighting and control building services (Section 13).

The LVAC system shall be comprised of two independent station power sources: from the auto transformers as per SLD. The station Auxiliary/Earthing transformer specification refers to the item 4.14 of section 4, Power Transformer, Volume 2.

Station power transformers shall be installed in designated location in the switchyard as preliminarily shown in the bid drawing. XLPE power cables may be used for connection from auto transformers to 33kV switchyard, as shown in the bid drawing and the connection from station power transformers to main distribution board shall be made with LV cables. Thus, independent cable route shall be secured in the trenches. The detailed design shall be approved by the Engineer.

In addition, the Bidder shall submit calculation report to determine the size of XLPE power cables considering current carrying current , short circuit current and earth fault current for PGCB’s approval.

VCB (33kV, 25kA, 630A/as per drawing) shall be used for the primary circuit breaker for station power transformer and ACB/MCCBs/MCBs (as per generally shown in the preliminary bid drawing) shall be applied for secondary. The secondary ACBs and associated other breakers (MCCBs/MCBs) must have mutual interlock function to avoid power source loss in any cases. The power shall be supplied independently through independent distribution switches as per the load categories such as: 400kV, 230KV, 132kV switchyard, each power transformer, main control building, local control houses and lighting

The AC station power system design shall be approved by the Engineer during the design drawing approval stage.

9.2 REFERENCES

IEC 60044 Instrument Transformers
IEC 60269 Low Voltage Fuses
IEC 60439-1 Specification for low voltage switchgear and control gear assemblies
IEC 60644 Specification for high-voltage fuse links for motor circuit applications
IEC 60898 Electrical Accessories - Circuit-breakers for overcurrent protection for household and similar installations
IEC 60947-1 Low-voltage switchgear and Control Gear - General
IEC 60947-2 Low-voltage switchgear and Control Gear - Circuit-breakers

IEC 60947-3 Low-voltage switchgear and Control Gear - Switches, disconnectors and fuse combination units
IEC 60947-4 Low-voltage switchgear and Control Gear - Electromechanical Contactors and motor starters

9.3 SWITCHBOARD DESIGN

9.3.1 General

Main switchboards and MCB sub-distribution boards for substation and building supplies will be constructed to IEC 439, (BS EN 60439) in accordance with the following:

The classification of the main switchboards shall be:

(a) The external design of switchboards shall be of the multi-tier, multi-cubicle type.
(b) Installation shall be indoors.
(c) Switchboards shall be free standing and fixed to the floor.
(d) Enclosures degree of protection shall be not less than IP52.
(e) Switchboards shall be of metal clad construction.
(f) All instrumentation and metering shall be fixed to a hinged lockable compartment.
(g) Switchboards and all associated equipment shall be suitable for use on a 415/240 volt, three phase, four wires, and 50 Hz system having the neutral solidly earthed.
(h) Each circuit shall be clearly labelled to show the destination of the associated cable and the “ON” and “OFF” positions of the switches.
(i) Distribution boards for exterior use shall be galvanised, weatherproof and to category IP55 degree of protection.

The equipment shall be of the single busbar type with circuit equipment housed in separate compartments.

Where two or more incoming circuit breakers are provided at substations, these shall be mechanically and electrically interlocked to prevent more than one circuit closing at the same time.

The enclosures of all switchboards shall be dustproof and vermin proof. Access doors shall be mounted using concealed hinges. All removable covers shall be fitted with captive screws. Anti-condensation heaters with control switches shall be provided on switchboards. They shall be suitable for a tropical climate.
LVAC system shall consider all the known future extensions.

9.3.2 Rating

Incoming supplies to all switchboards shall be protected at the point of supply. All

switchboards, breaker, equipment in LVAC distribution board or in the upstream level shall be suitably rated for a prospective short-circuit breaking capacity of 15 kA at 415V for 3 seconds and switchboards, breaker, equipment in switchyard, SPR & downstream of LVAC distribution board shall be rated of 10kA/6kA/4kA at 415V for 3s as appropriate. Necessary Calculation shall be submitted to the Employer for approval for justification of cascading low kA MCBs in the downstream.

9.3.3 Busbars

Busbars shall be capable of carrying the full rated current continuously without exceeding the maximum temperature specified in IEC 60439 under site ambient conditions.

Busbars shall be of copper, individually covered with a heat resistant phase coloured PVC. Busbar links between panels shall not be used. Neutral busbars shall have the same cross sectional areas as the phase busbars. Busbars shall be of the same current rating throughout their length and shall be capable of extension at both ends with the minimum disturbance to the busbar and cubicle enclosure.

9.3.4 Busbar and Circuit Shutters

For drawout equipment shutters shall be provided over busbar and circuit orifices to close automatically and positively when the equipment is isolated or withdrawn. Means shall be provided for padlocking the sets of shutters. Busbar orifice shutters shall be painted signal red and labelled ‘BUSBAR’ in white letters. Circuit orifice shutters shall be painted lemon yellow.

One blanking cover of each size shall be provided to prevent access to a circuit compartment when the equipment has been completely withdrawn from the panel.

9.3.5 Circuit Labels

Approved type title labels are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit list shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit list, the list and cover to be easily removable to permit circuit modifications.

9.4 CIRCUIT BREAKERS

All MCB and MCCB circuit breakers shall be high speed fault limiting, thermal/magnetic type with quick break, trip free mechanisms which prevent the breaker being held in against overloads or faults, shall comply with IEC 60947 and be fitted with overcurrent releases of both thermal and instantaneous type. Short circuit performance shall be to IEC 60947.

Where circuit breakers incorporate thermal overload protection and short-circuit protection, their settings shall be subject to agreement with the Engineer.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionising arc chutes.

Circuit breakers on the incoming circuits shall have facilities for locking in the “off” position.

The fault interrupting capacity of the circuit breaker shall not be less than that of the switchboard itself, or if this is not the case, back up fuses shall be included.

9.5 SWITCH-FUSES

Each switch-fuse unit shall be housed in a separate metal compartment and provided with a hinged metal door, interlocked with the switch mechanism so that:

(a) The door cannot be opened whilst the switch is closed.

(b) The door, on opening, automatically locks the switch in the “off” position. Facilities shall be incorporated to allow for the deliberate release of this interlock for maintenance purposes, should it be desired to observe the switch in operation.

An insulating barrier shall be fitted to segregate the fuses and neutral link from the switch and the connections of the latter shall be effectively shielded by an inner metal screen when the compartment door has been opened to obtain access to the fuses.

The switch-fuses may be either of the combination fuse-switch type or of the type with the switch and fuse in separate units. In either case, interlocking shall be provided to prevent access to the fuses until the associated switch is opened and provision shall be made for padlocking the switch in the “on” and “off” positions.

The switch shall have a quick make and quick break action, independent of the speed at which the switch handle is operated, and shall be entirely suitable for switching the inductive loads associated with motor circuits.

9.6 OIL FILTRATION SOCKET OUTLET AND PLUG

The Contract shall include heavy duty weatherproof three phase and neutral interlocked switched socket outlets and plugs suitable for supplying the transformer oil filtration units as per Schedule A of Volume 3 of this Bid Document.

9.7 INSPECTION AND TESTING

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.

SECTION 10

NATIONAL LOAD DESPATCH CENTRE (NLDC) CONTROL FACILITIES

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SECTION 10

NATIONAL LOAD DESPATCH CENTRE (NLDC) CONTROL FACILITIES

10.1 SCOPE

In Order to provide the tele-control & te-metering facilities required at the existing National Load Dispatch Centre (NLDC) at Rampura, the complete design supply, delivery, installation, testing & commissioning of new hardware and software, extension of the existing equipment, necessary adjustment, adaptation, modification, integration and configuration of new and existing equipment in NLDC , shall be provided for integration of new plants, in new and existing substations, which are in the scope of the work, under this Contract.

The NLDC is located in Dhaka (Rampura & Siddhirganj) and connected through a fiber optic network to communication equipment and Remote Terminal Unit (RTU)/Industrial Gateway of SAS system located at different power station/ substation.

The SCADA system of NLDC is based on GE Vernova e-terra platform.

The industrial gateway will be implemented at each grid substation for remote monitoring & control from the National Dispatch Centre. It will provide all necessary control and monitoring facilities for all voltage level lines, transformers and auxiliaries, capacitor banks, Reactors, Loadshed feeders.

All plant supplied under this contract shall be equipped with potential-free auxiliary contacts for indications and alarms, CT and VT circuits shall be fitted, where required.

Supply & installation of necessary equipment such as IED/relay, transducers, DI, DO card etc. for integrating new bay through existing RTU /Gateway at far end substation is supplier scope of work.

All HV breakers, motorized disconnectors, tap changers, Loadshed feeders etc. shall be controlled from NLDC through the gateway /RTU of the substation automation system using IEC 60870-5-104 protocol. Cabling between the substation automation gateway and the communication equipment shall be included in this contract.

Necessary modification in the software and hardware at NLDC master station is also to be done under this contract to accommodate all the new system extended under this contract.

In order to provide the telecontrol facilities required at the National Load Dispatch Centre (NLDC) the contractor shall supply & install 02(two) numbers of industrial gateway at new grid substation for integrating to NLDC SCADA system.

Data communication from switch to Gateway & switch to SAS server will independent.

The 02(two) gateways will be configured as master- hot standby mode.

All required electrical quantities (digital and analog) shall be transmitted to NLDC through the Industrial Gateway of the substation automation system (SAS).

The communication protocol to be used for data exchange between the NLDC and the substation shall be ***IEC 60870-5-104***.

The gateway shall be capable of reporting to both main master station at Rampura (through VLAN network) & the Standby Master Station at Siddhirganj (through routed network) simultaneously. It will be configured according to the signal list, communication parameter, IP address, station address etc. provided by PGCB.

Analog data measurement scaling shall be done at RTU or Relay (Preferable at relay). Analog data should be floating point. Analog data should be deadband with 0 %. Frequency dead band should be 0%. Digital data should be time stamp at field.

GPS is required at substation, so that RTU/Gateway can get exact time.

For securing SCADA system, hardware firewall device is required between RTU/Gateway and communication device at field, so any type of cyber intrusion or malware can be prohibited.

Necessary SCADA interfacing equipments such as Transducers, Digital input/output card, Cabling etc. is required for far end substation related to the substation.

Integration work

Integrating RTU/ Gateway with NLDC following work shall be done at Master Station Rampura, Dhaka and Backup station at Biddut Bhaban Dhaka. Scope of work includes
Pre database work:

a) Collection of network data for EMS application
b) Modeling, database creation, verification and update should be done at both NLDC
c) Modification and update of database for far end substation related to the new substation
d) The following should be done at Master station at Rampura and Backup station at Siddhirganj

1. SCADA Database Modelling
2. Substation Display
3. Network database Modelling
4. Generation Database Modelling
5. DTS Database Modelling
6. Alarm database Modelling
7. Validation

- Cross validation of all databases and create update copy of those databases.
- On-lining of databases in DTS (Simulator) server
- Checking and modifying (if require) topology of Substations, Devices, Network etc.

8. RTU/ Gateway configuration

Configuring the RTU / Gateway according to attach signal list , mapping address, data communication parameter, Source IP, Destination IP etc.

9. Local Test

The following test will be carried out at site using e-terracontrol software

- Verification of all Analog Measurement and checking of Limit, Deadband , Polling Time
- Verification of Digital signals Status (OPEN, CLOSE, BETWEEN, INVALID)
- Verification of ALARMS, EVENTS etc.
- Verification of Control and Interlock

10. Database Update

The following activities will be carried out in Master NLDC and Backup NLDC after successful site test.

- On-lining of all databases in Running Servers
- IP/VLAN Configuration on Polling servers and switch
- Compilation & On-lining of all the displays on WEB servers

11. End to End Test

The following activities will be carried out in Master NLDC and Backup NLDC

- Verification of all Analog Measurement,
- Verification of Digital signals and Controls
- Verification of displays including Single line, Pop up, alarms etc.
- Verification of communication line for Redundancy
- Verification of continuous and complete integration of the RTU/Gateway.

12. Tuning of Power System Application

- Tuning will be do required for all available Network and generation applications in SCADA/EMS server and DTS(Dispatcher Training Simulator)

Notes:

- Integrating RTU/Gateway with NLDC should be in the scope of work.
- Data communication path creation for both Main & Backup station is scope of Integration
- Collection of Network data required for modeling network database is in contractor's scope of work
- Contractor will conduct necessary work for both at NLDC & Substation (if required)
- Training is essential to realize the full potential of the Gateway/RTU.it is most efficient way to learn about the important features and operational procedures of the system.

10.2 REQUIRMENTS

10.2.1 Indications: Digital Input (Double Point)

The following indications shall be provided

-Circuit Breaker, Isolator & Earth Switch Open/ Close for line, transformer, bus coupler

-Circuit Breaker for Reactor/Capacitor bank & 33kv loadshed feeder

10.2.2 Load Flows, System Voltage and frequency

Electrical quantities shall be provided to enable the following measurements

- Voltage (kV), Frequency (Hz) for Busbar
- Megawatt(MW), MegaVar (MVAR), Amperes(AMP), Voltage (kV) for line
- MW, MVAR, Amperes, kV at both sides, Tap Position Indication (TPI) for Transformer
- Megavar, Amp & KV for Reactor/Capacitor bank

10.2.3. Alarms: Digital Input (Single Point):

- Remote/ Local Switch for all Circuit Breakers.
- Bay Fault (DC Fail for Transformer Panel).
- Breaker Fault (OR gate Spring Charge, SF6 Low).
- Protection Class-1 (Distance, Differential).
- Protection Class-2 (Over current, Earth fault).
- Protection Class-3 (bus bar).
- Transformer Alarm (Buchholz Alarm, Oil Level Low).
- Transformer Trip (Buchholz Trip, PRD Trip)
- Transformer Temperature Alarm (Oil Temp Alarm, Winding Temperature).
- Transformer Temperature Trip (Oil Temp trip, Winding Temperature trip).
- Tap Changer Alarm.
- Tap changer trip.
- Tap changer high limit.
- Tap changer low limit.
- Auto reclose operated
- DC fail
- AC fail
- Auto Reclose Block/OFF, Voltage Status, Ready Signal for Loadshed feeder

10.2.4 Controls-Digital Output (Double point)

The following facilities shall be controlled from the NLDC

-Circuit Breaker and Motorized Isolator Open/ Close for Line, Transformer bay & bus coupler,
-Circuit Breaker Open/ Close for 33kV load shed feeder
-Tap Changer Raise/ Lower for Transformer

10.2.5 Network parameters

Line length, Line Conductor type, Short Circuit data for Zero sequence (%R, %X, % of full charging Susceptance) etc.

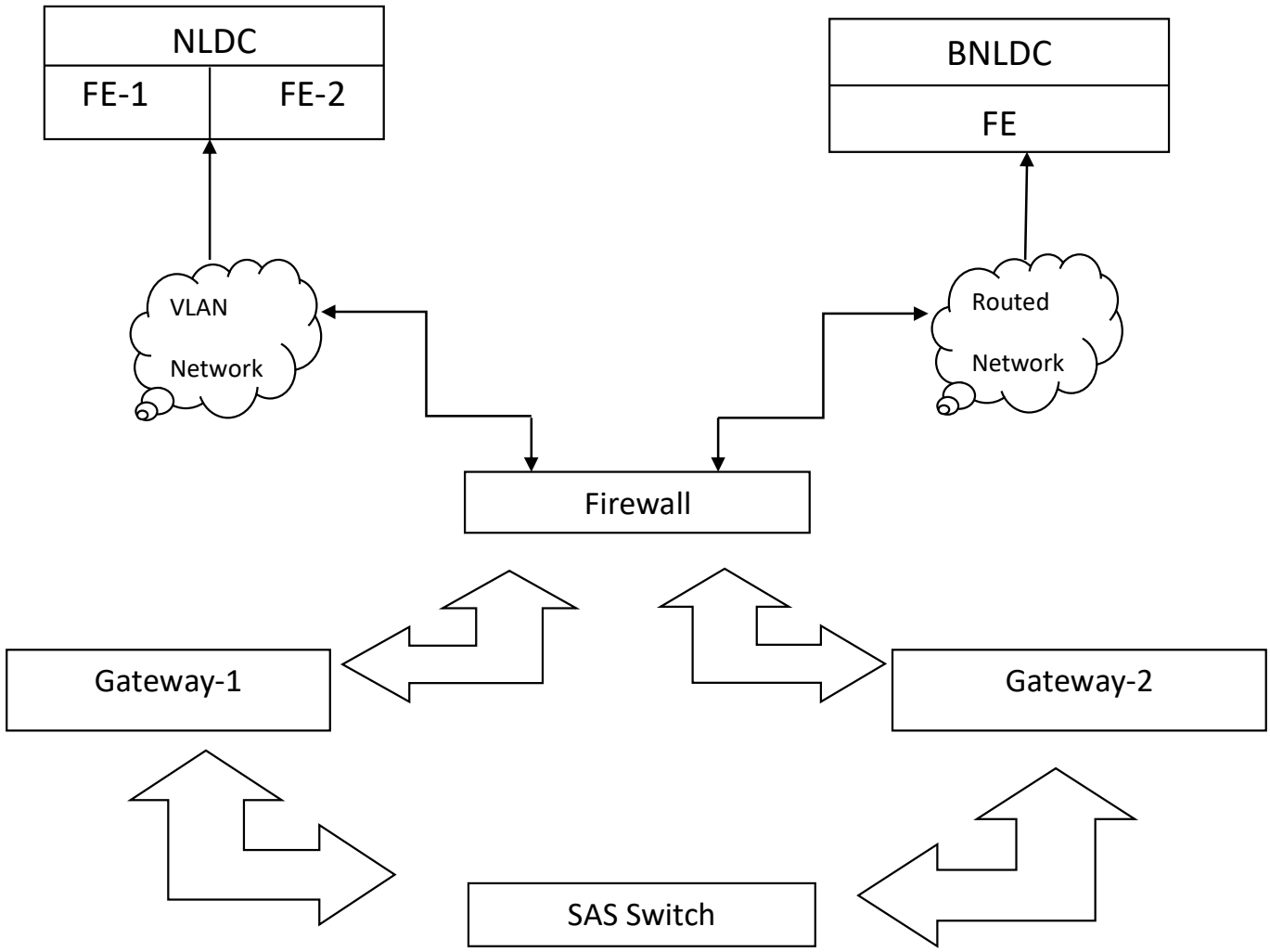
10.3 INTERFACES

This contract includes Industrial grade Gateway to the NLDC. The Gateway shall have adequate capacity to cater to the future extensions of substation. The cabling between the Gateway and the communication equipment shall be provided under this contract.

In case of Windows operating system based gateway, there should be USB port, VGA & HDMI Porty, HDD/flash memory with one spare, TFT monitor with mouse and key board etc. Hard disk should be 50% free and CPU loading maximum of 30% at any condition. If gateway is firmware based then 02(two) nos. of control card is required. Gateways also have 08 nos LAN port & Dual supply for both Firewall & Gateway. There should be GPS facilities for time synchronization. Also cyber security has to be ensured at field SCADA interface level. Supported Protocol shall be IEC 60870-5-104, 61850 & MODBus etc.

Operating System, all necessary software and system back up & restoration software (Acronis true image or Ghost or similar software) should be licensed and supplied in CD.

Conceptual Drawing of SCADA Communication Architecture



Note:

- ✓ SCADA Gateway and SAS Gateway shall be independent of each other.
- ✓ Both SCADA Gateways shall be capable of reporting to both Master & Backup station of NLDC simultaneously in HOT and STANDBY mode using IEC-104 protocol.
- ✓ Firewall shall be capable of communicationg with at least 3 different set of networks viz.
  - Substation internal network
  - NLDC Master Station
  - NLDC Backup station

OR

02 (Two) Nos of firewall may be provided to serve the purpose.

Conceptual Drawing of SCADA Communication Architecture

For any sort of support and maintenance SCADA & Maintenance divison approves of the following vendors for gateway purpose:

- ✓ ABB,Switzerland
- ✓ Schneider,France
- ✓ GE,UK
- ✓ Siemens, Germany

For any other vendors the contractor needs to provide proper training

Gateway GTP

Equipment	Specification	
Gateway	Manufacturer	ABB/GE/Schneider/Siemens
	Standards	IEC
	Nos	02 (Two); Configured as Hot-Standby
	Operating System	Windows Server Latest Version
	Rated auxiliary supply voltage	110Vdc or220Vac or compatible with the substation power supply system
	Dual power supply	Yes
	Processor type	Intel Xeon Gold or similar; CPU should not be busy more than 30%
	Processor clock	2.1 GHz (min)
	Memory type	8 GB DDR4 (min)
	Hard disc capacity	SSD with more than 50% free space
	I/O Interface	LAN Port: 4 (min.) x FE & GbE with RJ-45 Socket (Teaming function supported) USB Port: 4 (min) x USB 2.0 or above
	Operating Temp	0°C to 55°C
	Display	VGA & HDMI
	Spare Data Point	Gateway configuration software with proper license is required for future bay extension (at least 25% spare data point)
Firewall	Manufacturer	ABB/Cisco/Fortinet/Juniper/Hirschmann/Ruggedcom
	Stateful Inspection	Firewall Rules (Incoming/Outgoing, Management), IP masquerading, Port Forwarding, DoS Protection, ACL
	I/O Interface	LAN Port: 4 (min.) x FE & GbE with RJ-45 Socket Serial Port USB Port
	VPN	SSL and IPSec protected
	Protocols	Serial, HTTPS, SSH, SNMP
	Routing Functionality	L3 (Static & OSPF)
	VLAN Support	Yes
	Cyber Security	IEEE 1686 Standard
	Network Interface	Firewall must be capable of communicating with at least 03 different networks i.e. one with substation's internal network, second one with NLDC main station and third one with NLDC backup station. OR, Two nos of firewall must be provided to meet the purpose
	Rated auxiliary supply voltage	110Vdc or220Vac or compatible with the substation power supply system
	Dual power supply	Yes

COMMENTS ON SAS ARCHITECTURE for Power Transmission Strengthening and Integration of Renewable Energy Project (PTSIREP)

General comments:

1. SAS Servers and Gateways need to be **separate physical devices**.
2. **02 (two)** Nos of independent Gateway devices shall be provided with Hot-Standby configuration for reporting to both NLDC and backup NLDC simultaneously.
3. **Technical Specification, Manufacturer and country of origin of Gateway & Firewall** needs to be submitted for approval. Gateway and Firewall must be industrial grade.
4. **List of software** used in Gateways and Firewall needs to be submitted. All the Engineering tool/software needs to be supplied by the contractor for the feasibility of any further necessary modification of Gateway and firewall.
5. All the Engineering tool/software must have **English** in language option.
6. Gateway must meet technical criteria for taking and restoring **image backup**.
7. Contractor needs to provide at least 05(Five) years **warranty** on gateway and firewall from the date of Gateway and Firewall commissioning.
8. In case of unfamiliar gateway/firewall devices, **training** on configuring Gateway and Firewall needs to be carried out.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 11

BUILDINGS AND CIVIL ENGINEERING WORKS (FOR OUTDOOR AIS)

SECTION 11

BUILDINGS AND CIVIL ENGINEERING WORKS (FOR OUTDOOR GIS AND AIS)

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SECTION 11

BUILDINGS AND CIVIL ENGINEERING WORKS (FOR OUTDOOR GIS & AIS)

11.1 GENERAL

This section covers all earth work, foundations and buildings associated with the project together with site preparation, roads, surfacing, cable trenches and tunnels, boundary walls, guard houses, foul and storm drainage and water supply.

11.1.1 Scope of Work

The Tender must cover all requirements of the tender documents and any other items not specifically mentioned but which are necessary for the satisfactory design, construction, operation and maintenance of all substations to the satisfaction of the Employer. No additional costs will be considered for any items which have been overlooked but which are essential for the proper completion of the project in every respect. The detail scope of work for specific sub-stations is described in Schedule A of the bidding document.

The work includes but not limited the design, detailing, construction and maintenance of the following:

(i) Performance of site survey and subsoil investigation.

(ii) Site preparation including site slope protection, cutting or filling up to the level specified in 11.1.4 and levelling as well as compaction.

(iii) Foundations for all equipment to be installed in outdoor switchyards, control buildings and any other building required for the project.

(iv) Complete buildings consisting of structural reinforced concrete frames, brick walls, concrete roof and floor slabs.

(v) Road including access road with a culvert or sufficient drainage pipes and roadways within sites, surfacing the entire area within site boundary and surface water drainage.

(vi) Cable trenches, cable tunnels, cable ducts and pipe ducts.

For all substations and for individual rooms in substations suitable nameplates, signs and labels shall be provided to ensure identification, safe operation of plant and warning of danger. The text, which shall be both in Bangla and English, shall be approved by the Employer. The substation sign board(s) shall be 3 mm, Aluminum sheet powder coated and the text (Bangla & English) shall be UV resistant, Power Grid logo on a separate

circular plate to be fixed at the center of sign board. The inscriptions shall be engraved with colored lettering. All nameplates, signs and labels shall be non-deteriorating and non-warping under aggressive weather conditions and shall be guaranteed for a minimum period of 10 years. Plates, etc., will be securely attached using bolts and nuts or screws; adhesive will not be permitted.

Included in the scope of work is the detailing, construction and maintenance of the following items which shall generally be constructed to the Employer's standards but full working drawings shall be prepared by the Bidder:

(a) Guardhouse, sentry post, car port, stair railing, open store yard, pump house and chain linked fence

(b) Boundary wall and entrance gate

(c) Property line demarcation

(d) Septic tank and soak well

(e) Water supply tube well and plumbing installations

(f) Underground and overhead water storage tank

(g) Surface water, foul and storm drainage

(h) Air conditioning and ventilation

(i) Lighting, small power, external floodlighting, emergency lighting and fire protection

Guardhouse, sentry post, car port, stair railing, open store yard and chain linked fence as stated in item (a) shall be designed as per enclosed drawing.

Boundary wall and entrance gate stated in item (b) shall be designed as per enclosed drawings.

A drawing of septic tank and soak well as in item (d) above has been enclosed. The contractor shall construct septic tank and soak well following that drawing along with specifications provided in clause 11.3.3 of the document.

11.1.2 Bidder to satisfy himself as to all conditions

The Bidder shall assess:

(i) Access conditions at site, plus ground condition and ground bearing capacity.

(ii) Transport costs, materials costs and restrictions of availability of supply of materials locally.

(iii) Importation restrictions and delay due to customs controls.

(iv) Restrictions imposed by existing equipment on sequence of construction, access etc.

(v) Restrictions caused by cable laying and overhead line Bidders.

(vi) Ground conditions and temporary works required to provide support during excavation.

(vii) Adjacent distribution substation and their adjacent area of authority if any.

(viii) Availability of permanent bench mark at site.

11.1.3 Way leaves, Land Purchase and Planning Permission

The Employer will be responsible for the purchase of all land within the permanent site boundary and the purchase of all land required to the base of the fill of any batter slopes. The Employer will also be responsible for obtaining land to provide a permanent single access to site from a nearby road or waterway.

During the construction period the Bidder shall be responsible for maintaining this access road in a reasonable condition by reinstating damage caused by his construction traffic and Employer's traffic.

Should the Bidder require more than one single access to a site or require additional land for construction activities outside the permanent site boundary, he shall be responsible for the purchase or way leave of the required land.

The Employer will be responsible for applying for planning permission. The Bidder shall be responsible for completing the approved site survey and the approved site layout plan, together with the approved architectural elevations of all facades of any buildings, by the key date given in the programme so that the Employer may use these drawings to apply for planning permission.

11.1.4 Site Survey Drawings

For each site the Bidder shall prepare a survey at 1:200 scale showing existing ground levels on a maximum 10 meter grid and details of all features above and below the ground within the site boundary and up to 15 meters beyond it by the key date stated in the programme. Levels shall be related to bench marks clearly indicated on the plan. The plan shall be submitted to approval by the Engineer and the approved substation building plinth levels shall be given on site plan. The Bidder shall propose the building floor level to the Engineer. The Final Ground/formation Level (FGL) of the site will be 500mm above the crown of the nearest public road or

500mm above the Highest Flood Level (HFL) whichever is greater. If the site is located within/adjacent to an existing switchyard/substation of the employer/other organization, then FGL of the site should be determined same as mentioned above but should not be less than the FGL of existing switchyard/substation. For bay extension within an existing switchyard, FGL of new bay shall be same as the FGL of existing bay. All building plinth level will be 900mm above the FGL.

11.1.5 Earth Works

Fill where required shall be carried out by the Bidder. Source of fill material and Retaining wall shall be planned and approved by the Employer. The Bidder shall be responsible for providing a level or uniform sloping site to suit his substation layout design. The final ground/formation levels (i.e. the level below the brick surfacing) shall be stated on the site survey plan to be prepared by the Bidder.

11.1.6.1 Engineer's and Employer's Accommodation

On each major site the Contractor shall provide an office of approx. size 5 x 8m equipped with desk, one executive chair, two visitor chairs, one multipurpose shelf, light, fan and air conditioner, toilet with wash basin *etc.* for the sole use of the Employer's Engineer and his inspectors. Similar facilities are to be provided for the supervision consultant of the Employer.

11.1.6.2 Surveying Equipment

The Contractor shall loan his surveying instruments with surveyor to the Engineer and his staff when required. Instrument checks shall be carried out at monthly intervals. The specifications and user manuals of the instruments shall be submitted by the Bidder to the Employer.

11.1.7 Programme

The Bidder's programme shall at Bid stage define the following key dates. Where drawings are to be submitted for approval, they shall be submitted at least 28 working days before the key dates to allow for the Engineer to comment and his comments to be incorporated in the drawings:

1. Issue of approved site survey drawing within the site boundary and up to 15 meters beyond it complete with soil levels and floor levels.
2. Issue of approved electrical layout drawings.
3. Completion of Site Investigation field work.
4. Issue of approved Site Investigation Final report.

5. Completion of loading tests on a foundation on fill site and any other site where settlement is likely to be a problem.
6. Issue of approved drawings required for Planning Permission.
7. Issue of a full complete set of civil building drawings.
8. Construction starts date.
9. Date access will be given for:
    i) Installation of equipment in Buildings
    ii) Installation of outdoor plant
10. Construction finish date.

The drawing programme shall ensure that complete set of approved civil building drawings will be issued at least 14 days before construction start, in accordance with the Project Requirements.

The Construction programme shall be expressed in an 'S' curve for the whole project, with the percentage (of the total value of work in the schedules) each month.

11.1.8 Monthly Progress Certificates/Progress Reports

In accordance with the Project Requirements the Bidder shall submit agreed progress certificates before the seventh day of the next month. These certificates shall state the percentage completion of each item in the schedules and shall state the overall percentage completion. An updated 'S' curve shall be submitted with the progress certificates.

11.1.9 Temporary Facilities

The Bidder shall provide all temporary buildings, workshops, reinforcement, cement and lime stores and latrines required for his use. The Bidder shall agree the location of these buildings with the Engineer, after submitting a drawing showing their proposed location.

When a Bidder is placed in possession of a site, or part of a site, he shall erect temporary fencing immediately to protect the site until the boundary wall shall be erected.

11.1.10 Site Supervision

Although the civil and building works may be let as a sub-contract to an approved local Bidder, the main Bidder shall ensure that an expatriate supervisor in his direct employ is continuously available at site during construction. This supervisor shall have at least a working command of spoken English and be able to read, understand and discuss specifications

and drawings.

The Bidder shall notify the Employer and Engineer in writing of major field works three days before the work starts for the activities as described below:

i) Subsoil investigation.

ii) Every concrete pour and foundation casting.

11.1.11 Designs and Drawings

The Bidder shall obtain the Engineer's approval for the use of all design codes and standards before design work starts. The Bidder shall supply one copy of all of codes for employer's Engineer. If non-English equivalent National codes are adopted, the Bidder shall supply English translations of these Codes to the Engineer.

One copy of calculations along with all soft (software, excel sheet) copies shall be submitted together with drawings. To avoid possible misunderstandings, calculations will not be approved separately from drawings.

The Bidder shall generally submit a complete set of drawings with all soft copies (AutoCAD drawing) of each item sequentially for approval after initially getting the electrical layout and section approved. Where possible, drawings shall be standardized and general drawings shall be issued covering several sheets.

The Bidder shall provide a co-ordination plan at scale 1:200 showing busbar sizes, structure types, foundation types, cable trenches, roads, ducts, buildings, boundary walls, earthing, drainage and all services in this Contract.

11.2 REFERENCES

11.2.1 General

The design and construction shall conform to the latest edition of the relevant Codes and Standards. Any proposed substitution for the listed Standards by an equivalent Standard will be subject to approval by the Engineer. Relevant Standards include, but are not limited to, those listed in sub section 11.2.2 below.

11.2.2 Design and Construction Standards

BS12A Ordinary Portland cement

BDS EN 197-1 Portland Composite cement

BS EN 124	Gully and Manhole tops for vehicular and pedestrian areas
BS 812	Testing aggregates
BS 882	Aggregates from natural sources for concrete
BS 1377	Methods of test for soils for civil engineering purposes
BS 1722:	Part 10 Anti-intruder fences
BS 1881	Testing concrete
BS 2853	Design and testing of overhead runway beams
BS 3148	Methods of test for water for making concrete
BS 3921	Clay bricks
BS 4449	Steel bars for the reinforcement of concrete
BS 5262	External renderings
BS 5395	Stairs, ladders and walkways
BS 5572	Sanitary pipework
BS 5628	Code of practice for use of masonry
BS 5930	Code of practice for site investigations
BS 6031	Code of practice for earthworks
BS 6367	Code of practice for drainage of roofs and paved areas
BS 6399:	Part 1Code of practice for dead and imposed loads
BS 6399:	Part 2 Code of practice for wind loads
BS 6465	Sanitary installations
BS 6651	Code of practice for protection of structures against lightning
BS 6700	Design, installation, testing and maintenance of services supplying water for domestic use
BS 8004	Code of practice for foundations
BS 8005	Sewerage
BS 8100	Lattice towers and masts
BS 8102	Code of practice for protection of structures against water from the ground
BS 8110	Structural use of concrete
BS 8206	Lighting for buildings
BS 8215	Code of practice for design and installation of damp-proof courses in masonry
BS 8290	Suspended ceilings
BS 8301	Code of practice for building drainage

11.3 DESIGN

11.3.1 Architectural and Structural Requirements of Buildings

All new buildings shall be designed to be architecturally pleasing in

appearance and to withstand the tropical climate with minimal maintenance.

Architectural plan, all elevations and 3D view of buildings shall be agreed before other detail plans are prepared.

Air conditioning units shall be provided in rooms. Air conditioned rooms shall have a false ceiling such that the overall thermal transmittance of the roof shall be below 0.45 Watts/m^2°C. The false ceiling shall be made from non-combustible materials, and shall be easily removable to provide easy access to small power cables.

Control room building and switchyard panel room (SPR) building shall be designed by a reinforced concrete frame. The design base shear of the GIS/AIS and SPR building should not be less than 10% of the mass source. The definition of the mass source needs to be adopted from relevant code provision (BNBC 2020). Proper dynamic analysis for seismic design need to be performed where required. The design should satisfy all the parameters and seismic detailing as per the code provision.

The design of foundation, frame and slab of the control building, of which any part is subjected to vibration of machineries, should include a dynamic analysis. The purpose of the analysis and design should lead to a non-resonance condition. Proper scheme need to be taken in design and detailing of each component of the structure (foundation, frame and slab) to withstand this dynamic loading without any serviceability compromise in any events. If any measure of damping is provided by the manufacturer, then its installation method, amount of damping and other relevant data's need to be provided to the engineer and design should be done accordingly. A guideline can be taken from BNBC 2020 to estimate the effects for this kind of loading. Any established method (time history analysis *etc*.) for the dynamic analysis and design (for machine loading) might be adopted to ensure durability of the structure (foundation, frame and slab). An equivalent static method can only be used to support/verify the dynamic analysis.

An external concrete open staircase shall be provided up to panel room floor. An internal concrete staircase shall be provided up to the roof. The roof shall be a flat in-situ concrete slab designed for 2.5 kN/m^2 live load. For other buildings shall be designed as per latest BNBC.

The roof shall be waterproofed with application of two non-toxic components acrylic polymer modified cementations coating of minimum 1.5mm thickness for water proofing of roof which consists of powder and liquid acrylic emulsion; under a protective cover of patent stone/tiles. For waterproofing system minimum roof slope 1:150 shall be maintained.

Downpipes shall be of 100mm diameter uPVC pipe placed outside the wall

but shall be enclosed in a facing brick buttress. There shall be at least one downpipe per 100m^2 of roof. The Bidder shall guarantee the roof against leaks for a period of 3 years from the Taking over Certificate date. The roof shall project at least 450mm beyond the face of all walls or 150mm beyond the face of all columns whichever is greater to form a sunshade and rain shelter to the walls below. The upper surface of this projection shall be sloped and a drip provided.

The main entrance to all buildings shall be shaded, either by a projection of the roof over the entrance veranda or by a separate roof at a lower level. This area of roof shall also be waterproofed and drained by rainwater pipes.

The roof parapet wall shall be about 1.0 meter high with an in situ concrete coping of 75mm with *dpc* below it. Facing bricks/sand stone/fair face concrete or combination of them may be used at exterior wall surface in order to render aesthetic view of the control building. An architectural feature shall be provided by panels of open decorative block work to ensure good air circulation over the roof. Minimum three open decorative blocks of size 1000mm X 500mm should be provided on each side in solid portions of parapet wall.

The head of each downpipe shall be fitted with an enlarged hopper of 200mm and purpose made cast iron grill set into a recess in the roof projection.

All external walls of main control room building/SPR shall be minimum 230mm first class brickwork plus one layer of approved facing bricks/sand stone. External walls of other buildings shall be minimum 230mm first class brickwork plus one layer of approved facing bricks/sand stone or rendered with cement render and painted as required by the architectural plan. The internal walls shall also be generally of minimum 115mm thick first class brickwork. Internal walls and ceiling outside & inside of false ceiling shall all be rendered and receive one sealer coat plus two finishing coats of emulsion paint. Externally, rendered walls shall receive primer plus two finishing coats of acrylic external quality paint or similar approved.

Particular attention must be given in the design of buildings and layouts to fire prevention and safety of personnel at all times. Buildings housing switchgear and control equipment shall be designed as far as practicable to exclude pollution under all likely weather conditions. Fire-proof or flame-retarding materials are to be used for floor, wall and ceiling finishes. Where areas are designed as having a fire resistance rating then materials shall be shown to have passed approved standard tests for that class of fire resistance.

The minimum height of ground floor of two story control room building shall be 3.6 meter and the minimum height of first floor control room shall be 4.5 meter. False ceiling should be provided in the control room floor. In the switchgear rooms, minimum 1 meter clearance shall be provided over the switchgear to the underside of the roof slab but the Bidder shall provide a greater clearance if it is required to remove equipment. The clearance maybe reduced below down stand beams provided no equipment is required to be removed from the top of the switchgear. All rooms in any building in a story shall be of same height.

The false ceiling shall be made from non-combustible materials, and shall be easily removable to provide easy access to small power cables. Suspended ceilings, with acoustic tiling and incorporating lighting and air-conditioning fixtures shall be used in corridors, offices, toilet, control and SCADA rooms of the buildings and as per schedule of finishes.

In main control room building, all structures shall be designed to carry the loads imposed by the structure itself, together with minimum floor live load (including stairs) of 5.0kN/m2 (minimum) or in accordance with an approved standard or code of practice. The roof shall be designed for 2.5 kN/m^2 live load.

All doors opening outwards from the buildings shall be provided with panic latches or bolts which override any locking device, for escape in the event of fire. All doors shall be provided with overhead door closures of adequate capacity. Door labels incorporating electrical hazard warning in Bangla and English shall be fixed to each entry door. Vision panels shall be provided to frequently used doors.

Window openings shall be fitted with protruding concrete sunshades above and at the sides of the openings.

The domestic water supply system shall include all plumbing, underground pipework, high and low level storage tanks, valves, fittings and pumps (including the provision of a standby pump) for the provision of a pressurized water supply system for the static water tank and all buildings within the compounds.

On completion of the installation and prior to putting to use, the system shall be sterilized in accordance with an approved Code of Practice.

The Bidder shall be responsible for the provision and installation of a water supply serving the substation buildings. Every cistern, sink, basin, etc., shall be provided with as stop-cock in the supply pipe adjacent to the fitting. Each basin, sink and shower unit is to be provided with both hot and cold water. Provision shall be made for connection to the drinking water supply.

Each Toilet shall be provided with 1 no. western type WC, 1 no. wash-hand basin, 1 no. wall mounted mirror, 1 no. towel rail *etc.* all necessary fittings and accessories shall be provided.

Battery rooms shall be supplied with sink and drainer & exhaust fans (if no air conditioning).

The Bidder shall provide the fire/heat detector and portable fire extinguishers for main control building and local control houses. The fire extinguishers shall be of the dry chemical type suitable for the protection against Class A; B; C; fires. Each fire fighting units should be clearly marked as to its type and method of operation and of refillable-type cylinder. The details of installation for the fire/heat detector and portable fire extinguishers shall be provided to the Employer for an approval.

11.3.2 Ground Conditions, Foundations and Site Investigation

(a) Fill Sites

The Bidder shall impose the site layout on the survey to check for uneven depth of fill below any foundation and where uneven depth of fill exists his foundation proposals shall restrict final differential settlement to a 1 in 400 slope.

If a fill site has not been exposed to one wet season before foundation work starts, the Bidder shall flood the site to a depth of 50mm for 10 days (Not required on hydraulic fill sites). This requirement is because silty sands will generally compact to a denser condition on first time flooding.

On all fill sites the Bidder shall pipe rainwater from down pipes down to paddy level and shall prevent water ponding in open foundations and backfill all foundations as soon as possible.

When a filled site is handed over to the Bidder, the Bidder shall become responsible for maintaining the entirety of the fill in good condition, including all better slopes.

(b) Unfilled Sites

Original delta levels are generally below road level. Therefore most sites are historically fill sites but fill settlement can sensibly be considered complete, where fill is over 3 years old.

(c) Site Investigation

Detailed methodology for subsoil investigation shall be submitted before implementing the subsoil investigation. All laboratory tests shall be done at the test facility approved by the Employer.

The Bidder may appoint a sub Bidder to carry out the site investigation but all work and all lab work shall be witnessed by one of his Geo-technical engineer who shall countersign all recorded data.

1 borehole should be counted for every 600 square meter of proposed project area and provided on suitable points. At least three additional boreholes should be provided for control building and switchyard panel room building or any other building. For boundary wall/retaining wall additional boreholes shall be provided on in each corner point and at a maximum 50m interval point. Additional boreholes may also be required where uneven fill depth is encountered. The number and location of boreholes shall be approved with the site survey drawing showing existing ground levels specified in the section 11.1.4. The boreholes shall be located to an accuracy of $\pm$ 0.5m and shall be located to site layout considering existing obstacles at the field.

Boreholes shall be a minimum of 25 metres depth or twice building footing width or upto the level where the foundation/pile will be rest whichever is greater. All boreholes shall be backfilled with compacted sand.

Borehole log together with a summary of all required laboratory tests is required to be prepared. Soil test locations are required to be indicated on the geographical map.

In each borehole the following tests shall be carried out:

- Standard Penetration tests at 1.5 metre intervals.
- Undisturbed samples shall be taken at around 1.5 meters, 3.0 metres and 4.5 metres depth for unfilled site; 1.5 metres, 3.0 meters, 4.5 meters and 7.5 meters depth for filled site and tested by unconfined compression tests.
- One dimensional consolidation tests shall also be carried out on undisturbed samples taken at 1.5, 3 & 4.5 meters depth. The samples shall be saturated and the range of applied pressure shall fully reflect the in-situ conditions. Graphs showing void ratio (e) and applied pressure shall be submitted along with the Coefficient of Compressibility for the range of loading anticipated. Mv shall be in m^2/MN and shall be recorded at each stress increment. The coefficient of consolidation, cv, shall be given in m^2/year.
- Particle size analysis shall be carried out for each stratum and specific gravity, moisture content, liquid limit and plastic limit determined.

- Ground water level shall be determined by dipping the boreholes for 24 hours. Where collapse of the boreholes occurs, casing shall be used and left in until the water level remains constant for two days.
- In cohesive soils a vane test to BS 1377: Part 9 shall be carried out at three different depths. The Bidder shall check the sensitivity of soil and ground water at each site to concrete and take all measures necessary to ensure the long term durability of concrete.

The Bidder shall give the Engineer the requisite period of notice prior to commencing the geotechnical investigation at the field. The field sheets of each bore log shall be signed by the geo-technical engineer of Bidder and representative of the Engineer. The signed field sheets shall be include in site investigation report.

(d) Site Investigation Report

The site investigation and analysis of the data in a final report giving full details of foundation proposals shall be completed at each site by the programmed date. During site investigation, Geographical map shall be prepared indicating the locations of soil test.

The report shall be submitted by the key date at each site given in the programme. The Bidder shall submit 3 copies of the report to the Engineer. The report shall propose full details of foundations and loading thereon and shall provide estimates of likely settlements and differential settlements. The report shall be the work of the Bidder's own foundation engineers.

If the Bidder uses a local site investigation Bidder, he shall appoint one of his geo-technical engineer to oversee the entire operation and each piece of data shall be countersigned by this person.

Where estimated settlement exceeds 25mm, the Bidder shall construct one foundation at an early stage and test load this foundation to confirm settlement predictions.

(e) Foundations

Regardless of the result of soil investigation report, the foundations of main control building, switchyard panel room building and gantry structures, outdoor GIS/GIB foundation shall be provided with piles. Others buildings foundation shall be provided with shallow or pile foundation as per soil condition. Based on the site and soil conditions, auto-transformers and blast wall may be designed with mat foundation. Ground improvement need to be ensured by the contractor based on the underlying soil conditions. All earth retaining walls shall be RCC. Based

on site and soil conditions, boundary walls with/without RCC retaining wall may be designed with pile foundation or shallow foundation. Stability of surrounding and underlying soil must be ensured by the contractor. For footing supported boundary wall slope stability must be checked and necessary earth reinforcement techniques shall be adopted as appropriate.

Piles shall be concrete (cast-in-situ or precast) complying with BS 8004. For structural design of cast in situ piles, guidelines provided in **Annexure 11.1** should be followed. One working piles shall be randomly selected by the employer for pile load test in accordance with BS 8004. One working pile of control building, SPR building and one of auto-transformers at each site shall be compression load tested to 100% of design load and one working pile of gantry tower foundation at each site shall be uplift load tested to 100% of design load in accordance with BS 8004. Integrity tests shall be performed on drilled shaft concrete piled foundations selected by Employer for checking the uniformity, continuity and length of such piles using the acoustic pulse echo method shall be undertaken by a specialist subcontractor appointed by the Contractor. Details of practical experience of the subcontractor along with details of the test equipment, procedure of testing, presentation of test data/results shall be submitted along with tender. The integrity test shall be done at least one time for one pile selected by the Engineer. The actual method of performing the tests and the interpreting the results shall be subject to the Engineer's approval.

Other foundations of outdoor equipment shall be provided shallow/deep as per subsoil investigation report, settlement test as well as plate bearing test. In case of shallow foundation for outdoor equipment the bearing capacity of proposed soil level shall be checked by the plate bearing test. If the filling height of the substation area exceeds 4m, then foundations of outdoor equipment must be provided with pile foundation.

For shallow foundations the minimum depth of foundations shall be 1.5m.

All formations shall be hand rammed or mechanically compacted before placing 75mm minimum thickness of Class B concrete blinding, within 24 hours of bottoming excavation, which blinding shall project 75mm minimum distance beyond all footings. Each footing shall be inspected by the Engineer. Where soil condition is poor (on fill sites or already filled sites) or where the Bidder leaves foundations exposed and soil conditions deteriorate, one of the following measures shall be carried out as agreed with the Engineer:

i) Blinding depth and projection shall be increased as necessary.

ii) Soft soil shall be removed and replaced with compacted filling sand with the top 300mm (Minimum) consisting of sand and khoa (brick chips) in 2:3 ratio with 95% level of compaction.

The cost of this work shall be borne by the Bidder.

The Bidder shall propose the allowable bearing pressure for all foundations based on soil strength parameters only and shall not be increased while wind loads exceeds 25% of dead load as well as shall not exceed 125kN/m^2. Between column footings all walls, including all internal walls, shall be provided with a reinforced concrete strip footing of minimum dimension 800mm wide by 250mm deep placed at the same level as column footings and linked structurally to the footings. Column footings shall be tied at foundation/grade beam level and also floor level by beams to every adjacent column in both orthogonal directions.

The deepest parts of any foundations shall be completed first. All foundations shall be completed and backfilled, including all cable tunnel and cable trench work inside buildings, before walls are raised above floor levels. All other foundations shall be backfilled within 7 days of completing concreting.

All exposed concrete and the outer surfaces of cable trenches and cable tunnels shall receive three coats of bituminous paint before backfilling to reduce ingress of water. The Concrete surface shall be ground smooth and all air holes *etc.* filled (rubbed down with a cement slurry) before painting.

The Bidder shall monitor settlement of all foundations each month and report this settlement to the Engineer until settlement has reduced to less than 1.5mm in 3 months.

The tops of all foundations shall terminate 200 mm above site average finished surface level. All exposed edges shall have 20 mm x 20 mm chamfers.

Excavation shall only be carried out when the ground water table is at least 1000mm below foundation level. The excavation shall be kept dry during the construction period by providing sumps and pumps as required. During the rainy season, shelters shall be erected over all open excavations. For dewatering, slurry wall with required specific gravity may be used.

Excavations shall be adequately supported or formed to ensure stability of the sides and prevent any damage to the surrounding ground or structures. The design of suitable sheet piling and/or timbering for excavation shall be in accordance with the recommendations of BS 8004 Section 5.

When the Contractor requested shall submit details of his temporary support to the Employer.

Excavation shall not be carried out below or adjacent to existing building foundations until under-pinning and shorings have been completed by the Contractor.

The Contractor shall not permit water to accumulate in any excavation unless otherwise agreed. Any water whether arising from the excavation or draining into shall be drained or pumped to an approved location well clear of the excavation area in a manner that does not cause erosion, silting or contamination of existing drains and watercourses. Before the method of ground water lowering is selected, adequate knowledge of the ground and water conditions has to be obtained from the results of a soil investigation and/or information

The Contractor shall take adequate steps to prevent adjacent ground from being, adversely affected by loss of fines in any de-watering process.

Any over excavation shall be filled with Class B concrete.

All backfill shall be compacted to 95% maximum dry density as defined by BS 1377 test method part 4, 2.5 kg rammer.

Before starting foundation work the Bidder shall clear all sites of trees, tree roots, shrubs, debris, surplus soil, and any buildings.

Foundations shall be designed to resist uplift, assuming the water table is at ground level and the weight of soil resting on a foundation is that included within a 15˚ frustum.

11.3.3 Drainage

The entire surface within boundary walls shall be of uniform sloping site, sloping at 1 in 150 minimum slopes to open channels around the entire perimeter. These channels shall be designed for a rainfall intensity of 60mm per hour. Outside the boundary wall the Bidder shall be responsible for drainage up to 20 metres from the wall and will at some sites need to construct outlets with suitable erosion protection down to paddy level.

The concrete wall of cable trenches shall project at least 50mm above brick paving level to prevent run off entering the cable trench. The floors of all cable trenches/tunnels shall be sloped to soak well as described in 11.3.18.

The cable trenches will thus form barriers to surface water drainage. If the cut-off area exceeds $30m^2$ it shall be drained by constructing Water Catchment Pits (WCP) with a 200mm minimum diameter uPVC pipe to the

boundary drain. The Bidder's drainage design shall avoid all ponded water to avoid forming a mosquito breeding ground.

All drainage pipework within buildings shall be uPVC type, generally of 100mm diameter or as per requirement. Floor drains shall be placed in each battery room and toilet.

External pipework shall be 150mm. minimum diameter uPVC pipes at a minimum depth of invert of 300mm. Where pipes, including existing pipes alongside site, are less than 400mm above adjacent foundations they shall be surrounded in concrete. Where required, drainage pipes shall be kept below cables, allowing 1.1 m cover to top of pipes.

Manholes shall be of brick construction with minimum 450mm x 450mm clear openings and airtight RCC/ductile iron covers to BS EN 124. Manholes shall be located at each change of direction. Minimum fall on all pipelines shall be 1 in 150. Manholes shall not be located in roads.

The Bidder shall be responsible for all negotiations with local authority/WASA where a connection to a public sewer is proposed. Where high water levels in public sewers may cause effluent to back up into a site, no return valves shall be fitted. The Bidder shall provide all protection required to existing sewers and shall deepen foundations, including boundary wall foundations, where required to ensure all foundations are below adjacent sewers. The Bidder shall draw longitudinal sections of all pipelines.

Septic tank and soak well for Main Control Building shall be constructed as per provided drawings. The septic tank shall be located at least 15 meters from buildings/ water pumps. The pipe network for septic tank should be designed considering self-cleansing velocity. Inspection pits should be provided at regular intervals. Other buildings shall have septic tanks designed for the required number of users. All foul drains shall be vented by a vent pipe to above roof level. The inner surface of all manholes and septic tanks shall be painted with 2 coats of bituminous paint to protect it against sulphate attack. The septic tank shall have access holes directly over the inlet pipes and outlet pipes. Where public sewers exist alongside a site, the Bidder shall connect directly to the foul sewer, provided effluent from the sewer is treated.

The Bidder shall construct the drainage first to ensure that at no stage is rainwater ponded on any part of the site. All rainwater shall be able to run off the site or shall be immediately pumped off site by the Bidder. The Bidder shall complete all necessary drains before casting any roof and large concrete area which will create large run off. The condensate drains for the

air conditioning shall also be connected to the drainage. Bottom of drain shall provide adequate slope to achieve the self-cleansing velocity.

If a town's water supply is unreliable, the roof rain water shall be collected in an underground tank of standard Employer's design.

11.3.4 Surfacing

For the whole of the switchyard outdoor equipment area the ground shall be surfaced with gravel or other readily available local materials as approved by the electrical design. Gravels/other materials shall be clean, thoroughly washed when necessary, and free from clay, soil or contaminating material and shall be graded from 20 - 45mm except needed otherwise, laid and lightly compacted to a finished thickness of 175mm or as required by electrical calculations. Below the gravel/other material layer there shall be a 75mm brick layer with cement mortar (1:6), laid over a 75mm level of fine sand spread over the finished fill site.

Landscaping in the vacant space of substation area shall be done with acceptable tree plantation, flower gardens and turfing.

The substation plot, outside of the designated switchgear equipment areas, shall be turfed. Turf shall be of good quality, free from weeds and other impurities. Samples of the turf which is proposed to use shall be submitted to the Engineer for his approval. The turfs shall be laid to even surfaces on a bed of plastic/vegetable soil of 150mm thickness, which shall be raked and consolidated to provide a suitable bed.

On sloping surfaces the Bidder shall provide and fix wooden pegs to retain turfs.

All areas to be surfaced shall first be treated with a total weed killer in accordance with the manufacturer's instructions. Weed killer shall only be applied in dry weather when there is no risk of it being washed out to adjacent agricultural areas.

11.3.5 Roads

Access road from outside the site boundary to connect to any adjacent public road and all roads within the site boundary shall be provided by the Bidder. The road surface shall be finished by concrete paving or equivalent. All roads shall be of reinforced slabs of minimum 150mm thickness fitted with construction joints at distances not exceeding 6.0m. Paving schedule and methodology shall be approved by the Employer. The extent of roads required is shown approximately on Bid drawings but the scope of the work may change. Road layout shall generally permit vehicles to turn easily to avoid having to reverse out. Road layout shall be designed by the Bidder.

The bidder shall visit the sites and assess all practical requirements like culvert design & construction, removal of any obstacles, permission from local authorities *etc.* for access road. All necessary works shall be the bidder's responsibilities.

The width (between the outer edges of kerbs) of access road from outside the site boundary to connect to any adjacent public road shall be 6.0 meter. Width (between the outer edges of kerbs) of all roads within the site boundary shall be generally 6.0 meter transformer, 4.5 meter & 3.0 meter for sub road and 1.5 meter for walkway.

The road edge shall be formed by Class B concrete kerb 250mm wide by 400mm deep, placed over one layer of bricks laid flat. The road shall be a Class A concrete slab of minimum 150mm deep at each edge with 1:50 inward slope and stiff broom concrete finish reinforced with 10mm bars at 250mm centres longitudinally and 10mm bars at 250mm centres transversely placed 80mm below the upper surface. Expansion and contraction joins shall be detailed on site plans. Expansion joints shall be filled with hot bitumen & sand (2:1) sealant. Below the slab shall be a layer of polythene 0.5mm thick laid over one layer of 1st class bricks laid on edge in herringbone fashion in and on cement mortar (mortar designation iv) laid over one layer of 1st class bricks laid flat in and on a layer of sand laid on insitu soil which shall be compacted as agreed with the Engineer. If the soil is clay a 75mm drainage layer of broken bricks shall additionally be placed over the soil.

The radius of the road edge at corners shall not be less than 3 metres and 1.2 metres either side of the road shall be kept clear of obstacles. Bollards or raised kerbs shall be provided where required to protect items alongside a road from vehicles. Ducts shall be provided below roads for all services in this Contract and for all future services.

Where mortar designations are referred to see BS 5628 Mortar designation iv is 1 cement: 2 Lime: 8 to 9 sand.

At each new substation site a two bay hard standing car port, complete with sun shades, is to be provided adjacent to the control building.

11.3.6 Water Supply

The Bidder shall be responsible for providing a water supply both for construction and for operation of the completed sites. If a town's water supply is not available, the Bidder shall install one deep tube well for control building and another for ansar barrack/guard house of 40mm minimum diameter and 100m minimum depth with necessary pumps including all fittings, pipes *etc.* as required. But in that case guideline specified by WHO

for drinking water is required to be satisfied. The Bidder shall supply and commission power supplies and all pumps required by tube wells.

If a town's water supply is available, the Bidder shall be responsible for making all necessary arrangements with local authority/WASA to connect a supply. If the pressure in the supply is inadequate to supply the roof tank continuously, the Bidder shall install an 1800 litre low level tank and pumps. This tank shall be below ground with a 200mm minimum air void around the tank to protect it from contamination. The pump control panel shall be located in the building. Water levels shall be controlled by float switches but the panel shall provide also for manual operation.

The supply shall be connected to a 2000 litre food graded plastic tank. This tank shall be raised 400mm clear from the roof on four brick piers of minimum 350mm square. All supplies in buildings shall be fed from the roof tank. The supply to the tank shall have a valve at waist height. The tank shall have an overflow returning to the location of this valve. No pipes shall pass through the roof directly over any room. Pipework shall be routed up the outside of the building and return pipes shall return down the outside of the building before entering through the wall. Pipework shall be CPVC secured by clamps at 1.5 metre intervals and painted with alkyd paint to match walls. All pipes should be concealed by brickworks on vertical walls.

11.3.7 Plumbing and Sanitary Fittings

The Bidder shall prepare a drawing of all plumbing and building drainage for each building. Sanitary fittings and plumbing materials shall generally be of approved local manufacture.

In main control building each toilet shall have a single western WC. Each toilet outlet shall be vented by a 100mm diameter uPVC vent pipe passing up the outside of the building to 2500mm above roof level. Beside each toilet shall be placed a low level tap. Main control Building toilets shall also have a wash basin and cold and hot water shower with minimum 10gallon capacity geyser for each toilet. Toilets and showers shall have all walls tiled upto the bottom of false celling.

Every tap and cistern shall have stop cocks in the supply pipe. One external tap shall be provided on each building. Battery rooms shall be provided with a stainless steel sink of approximate dimensions 900 x 600 x 200mm with a draining board to one side. The battery room floor drain shall be connected to the foul drainage. All floor drains shall have P traps.

Mirrors shall be installed over toilet wash basins. Care shall be taken in orientation of toilets to avoid offending religious sensitivities. Toilets shall generally be orientated North-South where possible. Each shower shall

have a wall on two sides and a porcelain shower tray sunk into the floor. Soap dishes shall be provided beside each shower.

Only foul water from WC pans shall be connected to septic tanks. All other water shall flow to surface water drains.

11.3.8 Building Floors

All topsoil containing roots shall be removed and the insitu soil compacted before placing backfill. All backfill, including the backfill to column footings, below the floor shall be sand. The floor and all cable trenches shall be made of Class A concrete. The ground floor slab shall have a minimum 125mm thick reinforced Class A concrete and shall rest on the compacted fill. Below the slab shall be placed a layer of polythene 0.5mm and a layer of sand khoa (2:3) compaction of minimum100mm thick, hand rammed to a smooth upper surface.

All cables from cable trenches shall enter the building over grade beam level, no cable trench shall be allowed into main control room building. Where power cables traverse a building to reach a switchgear room on the far side they shall generally be contained within cable tray.

All sand backfill shall be compacted to 95% optimum density and shall be tested. The fill within a building, above ground level, shall not be placed until all backfill outside the building is completed. All floor slabs shall have a damp proof membrane of 0.5mm thickness.

Wherever required, control building shall have a ramp at a slope of approximately 1 in 7.5, of 1.5m minimum width with a Concrete Class A slab of min depth 125mm with a stiff brush concrete surface finish, or other agreed non slip surface.

All floors (including verandas) except for cable basement and battery room shall have mirror polished homogeneous floor tiles topping. The ground floor/cable basement floor shall be furnished with non-skid floor tiles. All external steps where public access is given to buildings shall have granite toppings.

Verandas shall have a minimum shed of 1:50 slope to rainwater away from buildings.

If floor tiles are not adequately durable to withstand switchgear movement when rolled out to the maintenance position, then galvanized steel chequered plates shall be inserted in the floor to resist the abrasion from switchgear wheels.

11.3.9 Cable Basement

Ground floor of the control room building shall be used as cable floor.

11.3.10 Battery Room Floors

Battery rooms shall have a concrete floor sloping to a cast iron floor drain. The concrete surface shall be treated with Nitocote epoxy resin coating (Nitoflor primer plus two coats of Nitocote in accordance with manufacturer's instructions), or similar approved material, to ensure resistance to battery electrolyte. There shall be no cable trenches in battery rooms. Cable entrances through the floor shall be protected by a raised plinth 50mm high around the opening with the annulus around the cable sealed after installation.

11.3.11 Control Room Floors

No raised floor except for panel installation shall be used.

11.3.12 Site Clearance, Obstructions and Adjacent Structures

The Bidder shall be responsible for clearance of:

(1) Trees, shrubs and any vegetation including the extraction of all roots and compaction of backfill where roots have been extracted.

(2) The removal of all buildings, sheds or any other structures above or below ground including the removal of any septic tanks, drains or other underground services.

(3) The removal of any existing surfacing, roads, foundations or any other obstruction.

All material cleared away by the Bidder shall be the property of the Employer and shall be removed by the Bidder to a site in the Project area upon instructions of the Employer. The Employer may remove any buildings or structures himself from sites before the commencement of site works.

Where an existing service, existing equipment or adjacent building is to be retained, the Bidder shall take all necessary measures to protect the item concerned from damage and shall be responsible for ensuring that no movement of foundations occurs during or after completion of construction.

Any existing electrical equipment/cables which have to be modified or repositioned shall be included in the works at no extra cost. Any buried gas or water main services which require to be diverted shall be deviated by the Employer at his cost. However, where it is possible to retain these existing services and build new structures around them, the Bidder shall take all necessary measures to build in the service at no extra cost.

11.3.13 Guard Houses, Boundary Walls, Fences and Entrance Gates

The guard house serves for control of entrance. The gatekeeper shall be able to watch the area before and behind the guard house. The guard house shall be provided with toilet, water supply facilitates. Small power and lighting facilitates are to be provided in the Guard Houses.

The Contractor shall base his design of boundary walls and gates following bid drawing and subsoil investigation report. Where sites are within existing Employer's boundary walls, the Contractor shall construct a permanent chain linked fence 1.5m high in accordance with BS 1722 part 10 or similar approved.

11.3.14 Windows

Even natural light shall be provided by windows to illuminate all areas of buildings. Window area shall be about 6% of floor area to limit solar heat gain. Tops of windows shall generally be minimum 2100mm from floor level but toilet windows may be higher. The bottom of windows shall be generally at least 0.45 metres above floor level. Each window shall be provided with a sunshade projecting about 350mm from the wall above and at the upper sides of the window. Few windows shall be placed on south facing walls. Windows shall be spaced to give a wide view of the switchyard.

Windows shall have single glazing with 6mm thick glass, reinforced with wire mesh where windows are placed in or over doors. For areas where wind speed exceed 250km/h, minimum 6mm thick glass tempered glass need to be used.

Window frames shall be anodised aluminium minimum thickness 1.5mm.

Glass panels shall be placed over doors to provide natural light to internal corridors and rooms where required.

External cills shall have a sloping tile or similar detail with drip.

The Bidder shall prepare a window schedule for each building.

The schedule shall clearly indicate both fixed and opening windows.

The Control and Switchgear rooms in particular shall have opening windows to allow adequate ventilation. Approved quality of MS grill shall have to be provided to all windows. All MS grill will be painted with one coat of red oxide primer and minimum two coats of approved quality synthetic enamel paint.

11.3.15 Doors

Internal doors and door frames shall be anodised aluminium with minimum

10mm thick tempered glass. Main Entrance/Exit doors and door frames shall be steel or anodised aluminium with minimum 10mm thick tempered glass.

The minimum size of the structural openings for doors shall be 1550mm wide for double doors and 930mm wide for single doors. Door height shall generally be 2100mm but switchgear and control rooms shall have a removable transom and removable panel over the door or a taller door to provide a total height of about 2100mm. All door sizes and widths shall be adequate to get in and get out all equipment and future equipment.

All external doors shall have weather boards, hydraulic closers and cabin hooks to hold the door open. External doors shall open inwards, except for switchgear room doors which must open outwards and be fitted with panic release latches.

Each wooden door leaf shall have minimum four 150mm heavy iron hinge. Door furniture shall be of approved local manufacture and shall generally be of brass. All corridor doors, external doors and rest room (toilet) doors shall be fitted with hydraulic closers. Door stops shall be fitted where required. Door frames shall generally be set 200mm off a wall junction to enable the door to open fully through 90˚.

All external doors shall be shaded by either the roof canopy of minimum 350mm or a separate precast concrete canopy over the top and the upper sides of a door.

The Bidder shall prepare a schedule of all doors and all door furniture for each building.

11.3.16 Brickwork

Brickwork shall be designed to BS 5628. External panels of brickwork shall be checked for wind pressure calculated in accordance with BS 6399 for a wind speed of 160 kph 3 second gust.

Bricks shall be first class bricks from approved manufacturers. 10 bricks shall be tested in accordance with BS 3921 to determine water absorption and crushing strength, which shall exceed 20N/mm^2. Mortar shall generally be mixed at a ratio of 1:5 (cement : sand).

All brick panels shall be tied to the concrete frame of approved design.

Facing bricks/sand stone shall be approved quality and size. Facing bricks/sand stone shall be tied back to the main wall of control room building/SPR. External walls shall be 230mm thick brickwork, rendered internally and clad externally with facing bricks/sand stone or rendered as required by the architectural plan.

Bricks shall be compacted down onto a full bed of mortar. Vertical joints shall be completely filled with mortar. Joints shall be raked out about 10mm deep where walls are to be rendered.

Brick walls shall be constructed so that tops of all meeting walls are about the same level. Only 18 courses per day shall be laid. New work shall be protected from sunlight and drying winds for 4 days.

Lime and cement for all brickwork shall be stored in a dry building with a raised dry floor.

Reinforcement by mild steel rods shall be provided where required by the design. Additionally openings over 500mm. wide shall be reinforced for 2 courses above and below the opening, minimum two 8mm bars per course extending 300mm beyond the opening both sides where possible.

All exposed brickwork shall be rendered and painted where not faced with facing bricks/sand stone.

11.3.17 Expansion Joints, Joint Fillers and Sealants

Not used.

11.3.18 Cable Trenches in Switchyards

Cable trench sizes shall be standardised. Layout drawings shall be submitted for each substation showing layout and size of trenches. No trench shall cross a road; power cables shall be placed in ducts of minimum 150mm diameter with bell-mouthed ends. Ducts shall extend 1500mm minimum beyond the edge of roads. Spare ducts shall be installed for likely future development.

Floors and walls of trenches shall be constructed of Class A reinforced concrete of minimum 150mm thickness, with the external surface painted with two coats of bituminous paint. Walls and covers shall protrude at least 70mm above site finish level and the top of the wall shall be flat with no rebate. Floors shall be sloped at 1: 150 minimum slope to brick soak well placed at the side of trench; the volume of each soak well shall be 2.5m^3 per 150m^2 of trench.

Covers shall be of reinforced concrete Class A. Each cover weigh less than 55 kg. The minimum depth shall be 70mm, with down stand ribs along each side providing a minimum overall depth of 100mm. The ends of the cover shall overhang the wall by 15mm and in the centre of each end there shall be a hand hole of minimum size 100mm by 20mm high. This hole shall allow air to ventilate the trench so that heat built up in the trench shall be reduced. No gaps larger than 5mm shall be left between adjacent covers so that the

cables are always shaded. Cover slabs shall sit squarely and uniformly on the trench walls without the need for bedding or shims. Because portable fire extinguishers will be rolled over and along trenches, each cover shall be capable of resisting a 250kg point load at mid span. The Bidder shall provide ramps up to the edge of covers in several locations, as agreed on site, to enable the wheeled extinguisher to mount the covers. Longitudinal edges may be inclined at 10˚ to the vertical, thus creating a larger gap at the bottom of adjacent slabs, again to reduce heat build-up. The upper surface of covers shall have a stiff broom non slip concrete finish. All sharp edges shall be stoned smooth. Outer edges shall be chamfered.

Longitudinal fire separation walls and transverse fire separation walls as required by the cable section, may be of brick or reinforced concrete.

11.3.19 Cable Trenches in Local Control Building/SPR

No cable trench shall be allowed into main control room building, all cables from cable trenches shall enter the main control room building over grade beam level.

Inside local control building/SPR, entry of cable trenches may be permitted. The base and walls of the trench shall be of reinforced Class A concrete of minimum thickness 110mm with the outside face painted with 2 coats of bituminous paint. Cable trays may be supported by Unistrut P3300 inserts, or similar approved or drilled anchor bolts.

The building layout shall minimise trench lengths. Where power cables pass through a building to reach the far side, this shall generally be in a tunnel section. The Bidder shall be responsible for providing all trenches and ducts in a building, including ducts for outgoing power cables up to the site boundary and including any pulling pits required.

Trench covers shall be sheets of composite board, PERMALI YA 729 or similar approved, consisting of wood fibres impregnated and compacted in synthetic resin, or a computer flooring composite board. The weight of each cover shall be restricted to about 30 kg. The upper surface shall be skid resistant. Deflection shall be limited to 1/250 of span under a load of 3kN/m^2. Only one thickness of board shall be used to standardize the edge support detail. The recess to receive the cover shall be protected by steel or brass on the vertical edge and bedding surface. Covers shall fit snugly around all cables. Where cables enter the building, all ducts/trenches shall be sealed. Fire/oil barriers shall be required to separate hazardous equipment. The ends of all ducts entering trenches shall be bell-mouthed.

Any beams used to support large span covers shall be removable. All metal work shall be painted as specified in the paint section.

All covers shall bed down evenly. Full detailed fabrication drawings shall be provided for all covers.

11.3.20 Rainwater Pipes

Down pipes shall be 100mm minimum diameter placed on the outside of walls but enclosed in a brick buttress of facing bricks/sand stone. One downpipe shall be provided for each 100m^2 of roof area. The head of the downpipe shall be enlarged to 200mm diameter and a purpose made cast iron grill provided over the head. This grill shall be sited in a recess in the roof slab projection.

The foot of the pipe shall have a 90˚ bend and water shall be discharged into either:

i) a small open channel conveying the water to the boundary channel

ii) a pipeline conveying the water off the site. Rainwater shall not be connected to the septic tank or allowed to discharge directly onto switchyard paving.

11.3.21 Switchyard Foundations

The tops of all foundations shall be set at the same level, which shall be raised above the Finished Switchyard Level (FSL) for the purpose of preventing surface water coming into contact with the equipment structures and holding-down bolts. The distance between the Finished Switchyard Level (FSL) and the top of foundations shall be at least 200mm. All exposed concrete surfaces shall be painted with an acrylic weather proofer or bituminous paint, and flat areas shall be sloped to shed water. No base shall permit ponding of water in any way, and free drainage shall also be possible from all areas inside any grouting.

Bases shall generally be of Class A reinforced concrete.

Bases shall have all recesses for cables and earthing detailed on drawings. The drawings shall clearly show the orientation of each base and the location of all recesses. Where new foundations are adjacent to existing foundations; the Bidder shall be responsible for verifying the extent of the existing foundation and ensuring its stability.

For anchorage design of switchyard foundations shear force, vertical accelerations, overturning moments and torsion due to mass eccentricities of the equipment for the earthquake load of 0.1G are required to be considered. Mild steel ductile bolts and headed studs cast-in-place anchor bolts shall be used. Thick plate washer is required to be welded to the equipment base plate. Normal washers shall be used under a nut in all

cases.

11.3.22 Transformer Bases

The transformer base, together with its surrounding bund shall form a raft to distribute the load from the transformer over the entire area within the bund wall. The bund shall extend at least 700mm beyond any part of the transformer and its radiators. The level of the top of the bund and the skids shall be 200mm above general switchyard level. Skids shall extend to the edge of the bund. Where separate transformer cooler banks are provided, the cooler banks shall also be protected by the bund.

50mm below the top of the wall shall be placed a layer of stone 225mm deep set on a galvanised grill painted with two coats of bituminous paint. The effective volume of the bund below the stone shall equal 125% of the total volume of oil in the transformer and its radiators.

Rainwater will tend to collect in the bund. To evacuate rainwater a fixed submersible pump controlled by sensors and switches (Aqua Sentry or equal) shall be provided at each bund with power supplies and drainage manhole conveniently located. The bund water control system shall differentiate between water and oil to ensure that the pump will not be activated while oil is present in the bund.

The transformer base and the bund shall be founded a minimum 1.0 metres below Finished Ground Level (FGL).

The skid walls shall be at least 600mm wide.

Top level of jacking pad should be at the same level of skid wall. Steel plates shall be inserted at the top of jacking pad.

The entire concrete surface of the bund and the transformer base which is not buried shall receive two coats of bituminous paint. Skids shall receive 3 coats of bituminous paint before being cast in.

Adjacent road (perpendicular to rail) shall be extended up to transformer bases. Width of extension shall be same as width of transformer. Transformer shall be anchored in such a manner so that it can prevent the movement of transformer for 0.2G ground acceleration.

11.3.23 Blast Walls

The Bidder shall construct blast walls to reduce the risk of fire spreading from each three phase transformer unit to an adjacent transformer unit or control building. IEC guidelines shall be followed for safe distance or fire protection of other structures near to the transformer. Blast walls shall also be constructed to resist impact forces causing from a transformer explosion

damaging adjacent equipment.

The height of the blast walls for transformers shall be 500mm higher than the tops of transformer or 500mm higher than the height of the tops of the HV bushing (whichever is higher) and 300mm wider at both sides than the width of transformer. The minimum thickness of blast walls shall be 200mm.

The blast wall will be constructed with Class A reinforced concrete with all exposed edges chamfered, Surface of wall will fare faced concrete and painted as the colour of transformer body.

11.3.24 Paints and Painting

All paints shall be of approved makes and colours and proven suitability for the prevailing climate and shall be approved by the Engineer. All surfaces for painting shall be cleaned down prior to being painted and rubbed down to a smooth finish.

All externally exposed concrete and render of the control buildings, boundary walls, blast walls and guard posts shall be painted with a fungicide, Snowcem primer and two coats of Snowcem. All exposed facing bricks/sand stone and Snowcern painted surfaces shall be treated with one coat of clear silicone (5%) water proofing solution.

All exposed parts of foundations, the outer faces of cable trenches and cable tunnels shall be painted with three coats of bituminous paint.

All non-galvanized metalwork shall receive two coats of red oxide paint at least 4 days before installation and shall receive two finishing coats of paint after installation, each coat being of different colour. Surface preparation before painting shall be SA 2.5 or an agreed rust convertor acid shall be used. All galvanized steel, boundary wall wire supports, crane beams, baseplates and holding down bolts and concrete plinths shall receive two coats of bituminous paint. Galvanized steel shall not be painted until the surface has weathered.

Internal walls when fully dry shall have the surface rubbed down with sandpaper and be painted with a sealer and 2 finishing coats of plastic emulsion paint before equipment is installed. A further finishing coat shall be applied after completion of installation.

One day shall be allowed for drying of each coat before the next coat is applied.

The interior of all septic tanks and manholes carrying foul sewage shall receive two coats of bituminous paint.

11.3.25 Furniture

The Bidder shall supply a complete set of tables, chairs, stools, desks, benches, storage shelves and drawing cabinets as described in the Project Requirements, Volume I with layout top, for drawing examination, lockable cabinets for spares and test equipment and key boxes in each control building. These shall generally be of steel of local manufacture and shall be of robust durable construction. In each rest room (toilet) two couches, approximately 900mm wide by 1900mm long with back rests against the wall, shall be provided.

The full details and specification of these materials shall be agreed before purchase. The Bidder shall arrange for a list of items to be handed over to the Employer, who will sign for receipt of a complete set as stated on the list.

11.3.26 Concrete

Only two class of concrete shall be used. Class A shall be used for all structural work, piling and for all foundations which are not unreinforced massive blocks. Class B concrete shall be used for blinding, pipe surround and unreinforced or nominally reinforced concrete. Road slabs and floor slabs all shall be reinforced Class A concrete.

	Class A	**Class B**
Minimum Cement Content	360kg/m3	170kg/m3
Maximum Water Cement ratio	0.55	-
Coarse Aggregate type	Well graded crushed stone chips	Jhama brick chips
Maximum Coarse aggregate size	20mm	25mm
Method of Batching	Volume batching	Volume batching
Minimum characteristic strength of trial mix at 28 days	30N/mm2	-
Minimum characteristic strength of trial mix at 7 days	14N/mm2	-
Minimum characteristic strength of works cubes at 28 days	20N/mm2	-
Slump Range	30mm min-100mm maximum	50mm minimum
Slump for concrete placed below water in piling	150mm minimum	-

It should be noted that minimum specified cement content will produce significantly stronger concrete. The Bidder's design shall be based on a 28 day crushing strength of minimum 20N/mm^2. Design shall be in accordance with this Contract and BS 8110 or other agreed standard.

For all types of foundation work mild steel of minimum characteristic strength 415 N/mm^2 shall be used and minimum reinforcement required for pedestals and foundation bases shall be 0.5% and 0.15% of gross cross sectional area respectively.

Minimum cover to rebar shall be 60mm where concrete is in contact with backfilled soil against a shuttered face, 75mm where concrete is cast against soil, and 38mm for all above ground concrete. In detailing bars which traverse a member, a reduction of 5mm shall be made for a bent bar and 10mm for a straight bar to ensure adequate cover. Exposed ends of sunshades and roof projection shall have 70mm minimum cover.

All concrete design shall ensure easy access for vibrators of 50mm. minimum diameter. Because of the slowness of concreting using local methods of transport, congested reinforcement details and shapes which are difficult to concrete should not be used. The location of all cold joints shall be agreed in writing with the Engineer and all joint surfaces shall be scabbled. All joints shall be horizontal or formed against vertical stop ends. Shear key shall be provided in joints. All cold joints shall be indicated on drawings. Roof slabs shall generally be cast in one continuous operation. Where curing compounds are used to protect exposed surfaces from solar radiation and improve moisture retention, they shall be subject to the approval of the Employer. This is a **Hold Point**.

11.3.27 Concrete Reinforcement

The Bidder may use locally available mild steel bars from approved sources or import steel bars to any agreed standard. No bar or stirrup shall be smaller than 8mm diameter to ensure adequate rigidity during concreting.

If locally purchased bars are used, bending tests and tensile tests shall be carried out to ensure the bars meet the design standard adopted and weight per unit length shall be tested regularly.

Bar bending lists shall generally be shown on drawings, where possible with a diagrammatic representation of each bar to ensure clarity and ease site communication. The Engineer will not systematically check the accuracy of every bar on bar lists when approving drawings. The Bidder shall therefore arrange to check all bar lists. Drawings shall detail all chairs and ties and include these on bar lists.

Bars shall be tied at every intersection and the ends of tie wire bent away

from concrete surfaces.

Anti-crack bars shall be provided at changes in slab or wall thickness and at the corners of every rectangular opening.

11.3.28 External Render

All brickwork which is not faced with facing bricks/sand stone shall be rendered. Concrete columns and walls shall be rendered and painted in accordance with BS 5262 with a 3mm spatter dash coat a 12mm undercoat followed by a 9mm finishing coat. Surface preparation shall be as described in BS 5262. Joints shall be provided in all render where brickwork panels abut concrete columns and grade beams, as required by BS 5262.

A mix type II or III shall generally be used. The finishing coat shall be weaker than the undercoat.

The tops of all foundation blocks and all protruding concrete foundations shall also be rendered where required by the Engineer.

PVA Bonding agents shall not be used because of the risk of early drying in the tropics. All concrete surfaces to be rendered shall have the entire surface scabbled and brushed with a stiff brush to remove all loose material. The surface of the undercoat shall be roughened to ensure bonding of the finishing coat.

All render once completed shall be kept continuously damp for 10 days, after which if shall be treated with a fungicide. Any existing backgrounds shall be treated with a fungicide and all growth cleaned after 5 days of contact with the fungicide.

11.3.29 Goalposts

In each outdoor switchyard with live conductors crossing roads the Bidder shall erect a permanent goalpost at the edge of the danger area with red and white metal warning boards hanging down from the goalpost to warn high vehicles of the overhead danger. This structure shall conform and match those supporting structures in Section 12 of this Contract for the high voltage switchgear.

11.3.30 Modification Works

In bay extension/renovation works of existing substation, sometimes modification of existing structure and or foundation may be required. The contractor should asses the existing structure and or foundation for modification. Necessary modification works should be done to install new equipment. If modification of existing control building is required, it must be

done without any structural damage to the existing building. The modification work must be done keeping similarity with the existing structures.

The contractor should bear full responsibility of any modification done by them. Before starting of the modification work, the modification proposal must be submitted to the employer for approval.

11.3.31 Stairs

Except where indicated otherwise in the schedules, all single/multi story buildings shall have internal/external staircase up to the roof; the minimum staircase clear width shall be 2.5metre and the maximum slope about 30˚, all detail being designed in accordance with BS 5395. These staircases shall be enclosed. The design shall allow free circulation of air over the treads and through the risers. Non slip nosings shall be provided.

Main control building shall have one internal and one external staircase, which shall have a minimum clear width of 2.5metre with a maximum slope of 30˚, all detailed in accordance with BS 5395. External staircases shall not be enclosed but shall be completely protected against rain by roof projections; steps shall be open with non-slip nosings. Internal staircases shall have homogeneous floor tiles with non-slip nosings. All staircases shall be provided with stainless steel railings.

All roofs which are not accessible by stairs shall be provided with a galvanised steel fixed ladder.

11.4 CONCRETE WORKMANSHIP

11.4.1 General

At all stages in the production, mixing, placing and curing of concrete, the work will be inspected by the Engineer's representative. If any material, dimension or practice is not at least equal to the standards set out herein, it shall be rejected and alternatives compliant with the said standards, and in addition to the satisfaction of the Engineer, shall be implemented.

11.4.2 Aggregates

Coarse aggregate shall be capable of passing through a 20mm sieve and be retained on a 5mm sieve. Fine aggregate shall be not larger than 5mm and not smaller than 0.06mm and shall be sharp in texture.

All aggregates shall be free of harmful quantities of organic impurities, clay, silt, salt or unsound particles. The amount of clay, silt and fine dust present in aggregate, whether as coatings or separate particles, may not be more

than:

15% by weight in crushed sand 3% by weight in natural or crushed gravel sand 1% by weight in coarse aggregate.

If the Engineer considers that any aggregate which the Bidder proposes to use contains an excess of fine particles or any harmful substances, the Bidder shall either replace the aggregate or, at his option and entirely at his expense, institute a series of approved tests at an approved laboratory to determine the nature and extent of the fine particles and harmful substances. Following receipt by the Engineer of the results of the analysis and tests, he will advise the Bidder in writing whether the proposed aggregate may or may not be used. The Engineer's decision in this respect shall be final.

Tests to determine the extent of impurities or fine particles shall include (but shall not be restricted to) the relevant tests specified in BS 882:1992, ASTM. C40-79 (Colorimetric test) and ASTM. C33-82.

11.4.3 Sampling

At least four weeks before he envisages first receiving aggregate from any source the Bidder, in the presence of the Engineer, shall obtain samples for testing. Samples shall be taken in accordance with the procedure quantities laid down in BS 812 and shall be subjected to those tests which the Engineer considers necessary to demonstrate the soundness of the material.

Such tests shall be carried out in an approved manner at the Bidder's expense and may include the manufacture, both in the laboratory and at site, of test cubes or cylinders to determine crushing strength.

11.4.4 Grading

The Bidder shall ensure that his offer includes the full cost of obtaining and transporting suitably graded stone aggregates to site.

Grading of aggregates should, together with the required minimum cement content and water cement ratio, ensure adequate durability, density and characteristic strength of the finished concrete. The Bidder shall submit in writing to the Engineer the makeup of the mix he proposes to use, together with the grading analysis for the particular material and any details concerning his or others' experience with the use of aggregate obtained from the same source.

11.4.5 Cement

Ordinary Portland Cement shall comply with BS 12A or Portland Composite Cement shall comply with BDS EN 197-1. The Bidder may obtain cement,

bagged or in bulk, from any approved source in Bangladesh but shall always submit sufficient samples from each delivery, as required by the Engineer, to ensure that all cement complies with the minimum requirements of BS 12A or BDS EN 197-1. All cement shall be stored in a weather tight shed at least 300mm off the floor to prevent the moisture. Regular checks shall be made on the weight of cement in each bag.

11.4.6 Water

All water used in the preparation of concrete for foundations shall be potable water, *i.e.,* clean, fit for drinking and free from all earth, vegetable matter and alkaline substances, whether in solution or in suspension, and shall comply with BS 3148.

11.4.7 Reinforcing

Where reinforcing is specified in any foundation design, it shall comply with BS 4449 or an approved similar standard. Before any reinforcing is used, the Bidder shall provide the Engineer with a certified mill certificate, verifying its grade and quality, and proof test such samples as the Engineer considers necessary. All reinforcement shall be clean and free from loose mill scale, dust, loose rust and paint, oil or any other coating which in the opinion of the Engineer may destroy or reduce bond.

11.4.8 Storage

The Bidder shall ensure that all the materials he provides for the preparation of concrete shall be stored in a manner which prevents contamination by dust, clay, water or any other harmful material.

Heaps of coarse and fine aggregate shall be separated by at least one metre.

Where aggregate is tipped directly onto the ground, the bottom 20cm of the heaps shall not be used. Bagged cement shall be protected from rain, mixing water or damp soil during storage/transport. Cement from accidentally split or damaged bags shall not be used.

Where the Engineer considers it necessary, special precautions shall be taken to ensure that aggregate stored on site shall remain dust free. Such precautions may include the bagging of aggregate at the pit if sites are adjacent to dusty roads or if heavy rain is liable to wash out fine material or saturate the aggregate to an extent which might influence the water content of a mix.

Where the Bidder establishes central depots for receiving cement prior to despatch to individual sites, he shall ensure that the cement storage areas

are sufficiently raised above the surrounding ground to prevent contamination of the cement by surface water. The material from which storage plinths are made shall be approved by the Engineer.

11.4.9 Design Mix

Prior to ordering any aggregate the Bidder shall inform the Engineer of the source(s) of his aggregates and deliver samples to the Engineer. The Bidder will authorise at an approved laboratory tests to show the sieve analyses, relative densities, moisture content and specific gravity of the samples of aggregate from each source. At least four test specimens of concrete shall be mixed at an approved laboratory and tested after 7 and 28 days.

Depending on the moisture content of the samples of aggregate the Bidder will report to the Engineer on the expected water/cement ratio and the aggregate/cement ratio of concrete to be produced on site.

Following the successful testing of the laboratory samples the Bidder shall make trial mixes at site (from which he will take at least 4 test specimens) using the proportions advised to the Engineer (and in the presence of the Engineer) and using the equipment he intends to use in the normal day to day manufacturing of concrete. The minimum 28 day crushing strength of any such test specimen shall be not less than 20 N/mm^2.

After successful testing of the test specimens made at site, the Engineer may then approve the source(s) of aggregate and the mix design.

No changes to the approved mix design will be permitted unless the type or source of aggregate differs from those already tested, in which case further tests at both the laboratory and at site will be made.

Any concrete placed which does not conform to the approved mix designs, shall be removed and replaced by the Bidder at his own cost.

11.4.10 Mixing and Placing of Concrete

Proportions of aggregates and cement and the quantity of water for each batch of concrete shall be closely monitored by an experienced mixer operator. Aggregate shall preferably be weight batched but, where this is not possible, volume batching shall be permitted, provided that the net volumes of the loading equipment are approved by the Engineer. Containers for measuring quantities of water shall be clearly marked and only approved quantities of water shall be used in the manufacture of concrete.

Mechanical mixers shall be in good condition and well maintained. After loading, the constituent parts of the concrete shall be mixed together for a period of not less than two minutes or 30 revolutions of the barrel, whichever

is the greater. For mixers with a capacity greater than 1.5m^3 these periods may be increased if the Engineer so requires.

When the constituents are adequately mixed, the fresh concrete shall be discharged from the mixer and placed in the foundation with the minimum of delay. Chutes shall be used to ensure that fresh concrete is not dropped by more than 1.5 metres.

No concrete shall be placed until all form work, installation of parts to be embedded, and preparation of surfaces involved in the placing have been approved. No concrete shall be placed in or through water, except with the written permission of the Engineer, and the method of

depositing such concrete shall be approved by the Engineer. Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened for seven days. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, mud or other foreign material, shall be cleaned of all such refuse before the surrounding or adjacent concrete is placed. Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and other foreign matter. The surfaces of concrete which have set, and against which new concrete is to be poured, shall be thoroughly cleaned to remove all foreign material and laitance, and be saturated with water immediately before placing concrete. Concrete shall be deposited continuously and as rapidly as possible until the unit being poured is complete. If for any reason the work is stopped before completing the unit of operation, a construction joint shall be installed in accordance with the instructions of the Engineer. Concrete shall be so deposited as to maintain, until the completion of a unit, a plastic surface approximately horizontal.

The method and equipment used for transporting concrete shall be such that concrete having the required composition and consistency will be delivered as near as practical to its final position without segregation or loss of slump. All concrete mixing and placing equipment and methods shall be subject to approval by the Engineer. Concrete placement will not be permitted when, in the opinion of the Engineer, weather conditions or other pertinent factors prevent proper placement and consolidation.

Bidders are reminded that, as a minimum standard, the following series of inspections should be carried out by the Bidder before concreting can begin:

1 Formwork coated with mould oil and correct in type, quantity and condition

2 Centre lines of template to coincide at the centre peg

3 Formwork to be well strutted and correctly located

4 Vibrator to be in working order

5 Mixer to be in working order

6 There is provision to maintain continuous mixing and pouring, by hand if necessary, in the event of a mixer breaking down

7 Where necessary, re-bar is on site ready bent and complete with tie wire, stirrups and concrete or plastic preformed spacer packs

8 A reliable level is at hand

9 There is sufficient aggregate, cement and water to complete the pour

10 Excavations are safe and not cluttered around the top edges

11 The mixer barrel is clean, and the paddles are complete and in place and the barrel will rotate at the speed specified by the Manufacturer

12 A suitable chute is in place

13 Both an air thermometer and concrete thermometer are on site

14 There is a large quantity of hessian sacking at hand

Where any of the above items are not complied with, the Engineer may suspend concreting pending their implementation.

11.4.11 Testing of Concrete

Samples shall be taken and tested in accordance with BS 1881. Testing shall be carried out by an approved laboratory, who shall arrange to immediately notify the Bidder and the Employer in writing of any cube failure. Failed cubes shall be kept for reference.

Concrete for the test specimens shall be taken at the point of deposit. To ensure that the specimens are representative of the concrete, a number of samples shall be taken from different points. Each sample shall be large enough to make one test specimen and shall be taken from one point in the work.

The tests specimens shall be stored at the site at a place free from vibration, under damp sacks for 24 hours $\pm$ 1/2 hour, after which time they shall be removed from the moulds, marked and stored in water at a temperature of 10˚ to 21˚C until the test date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in damp sand or other suitable damp material, and shall reach the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in

water until the date of the test.

One compression plate of the testing machine shall be provided with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the plate. Test specimens shall be placed in the machine in such a manner that the load is applied to the sides of the specimen as cast.

Cube strengths for concrete are to be not less than 14N/mm^2 within seven days after mixing and 20N/mm^2 within 28 days after mixing.

One cube shall be tested at 7 days to obtain an indication of the concrete strength. The remaining three cubes shall be tested at 28 days and the average of their strengths shall be calculated. Should the average of the cube strengths fall below the specified 28 days cube strength, the Engineer may order the affected concrete to be removed and replaced at the Bidder's expense, or the Engineer may allow the Bidder to take a cylinder for further testing in accordance with BS 1881, if Schmidt Hammer readings indicate below strength concrete.

The diameter of the cylinder shall be not less than three times the size of the maximum aggregate and its length will be at least double the diameter, after allowing for preparation and facing prior to the test. Both a report and compression test will be completed for the sample in accordance with BS 1881. Only one such test will be permitted from any one sample and if the crushing strength of the sample is in excess of that required by the design the Engineer may, after the Bidder has made suitable repairs to the part disturbed by taking the sample, accept the concrete.

11.4.12 Formwork

All formwork shall be steel. Formwork shall conform to the shape, lines and dimensions of the concrete as called for on the Plans and shall be sufficiently strong to carry the dead weight of the concrete without undue deflection or bulging, and sufficiently tight to prevent leakage of mortar. It shall be properly braced and tied together so as to maintain position and shape. Members used in forms at exposed surfaces shall be dressed to uniform thickness and shall be free from loose knots or other defects. Joints in forms shall be horizontal or vertical. Formwork shall not be disturbed until a minimum of 48 hours has passed from time of placement and concrete has hardened sufficiently to support any construction loads that may be imposed. When stripping forms, metal wedges or tools shall not be used to pry panels loose. If wedging is necessary, it shall be done with wood wedges lightly tapped to break adhesion. All columns and beams will have exposed edges chamfered 20 mm x 20mm. Formwork stripping time should

be as per standard code and practice.

11.4.13 Reinforcing Steel

Steel reinforcing bars shall be positioned in the concrete at the places shown on the drawings, or where reasonably directed by the Engineer.

Before reinforcing bars are placed in position, surfaces shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease and all foreign matter. Once in position, reinforcing bars shall be maintained in a clean condition until they are completely embedded in concrete. Reinforcing bars shall have at least the minimum concrete cover shown on the drawings. Reinforcing bars shall be accurately placed and secured in position, such that they will not move during placing of concrete. Precast concrete block spacers may be used for supporting reinforcing bars.

11.4.14 Consolidation of Concrete

Concrete shall be consolidated to maximum practical density, without segregation, by vibration so that it is free from pockets of coarse aggregate and closes against all surfaces and embedded materials. Vibration of concrete in structures shall be by electric or pneumatic-driven immersion type vibrators of 50mm minimum diameter, operating at speeds of at least 8,000rpm when immersed in concrete. The vibrator shall be inserted vertically at close enough intervals so that the zones of influence overlap. The vibrator shall be inserted to the full depth of the layer being treated and withdrawn slowly. When concrete is being placed in layers, the tip of the vibrator shall extend approximately 100mm. into the underlying layer. Vibrators shall not be used to move concrete horizontally. Care shall be exercised to avoid over-vibration of the concrete and direct contact between the vibrator and reinforcing shall be avoided.

11.4.15 Curing of Concrete

For foundations where excavations are to be backfilled immediately following the striking of shutters, the concrete is to be thoroughly wetted before backfilling commences. Where shutters are to be struck and backfilling of the excavation is not to take place immediately, the concrete is to be covered with wetted hessian sacking and be enclosed in polythene sheeting to avoid rapid drying of the concrete. Curing period should be as per ACI 308R-01 guidelines.

11.4.16 Hot Weather Concreting

In hot weather the following additional precautions shall be taken.

(a) In hot weather suitable means shall be provided to shield the aggregate stockpiles from the direct rays of the sun or to cool the mixing water/aggregates to ensure that the temperature of the concrete when deposited shall not exceed 32˚C.

(b) In hot dry weather suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the final concrete.

11.5 WORKMANSHIP OF ALL OTHER MATERIALS

This specification only describes concrete work in detail. All other materials workmanship shall be in accordance with an agreed standard. Before starting any new item of work the Bidder shall submit samples of the materials to the Engineer for approval in writing and the method of installation shall also be approved. The first item of any type to be installed shall be inspected and checked in detail by the Engineer before other items are constructed.

11.6 Land development work:

11.6.1 Land development work shall be carried out by dredged filling material or by carried earth/filling sand using the following methods or any other suitable method:

(a) Land development by dredge filling material:

Land development by dredge filling materials means dredging by cutter suction dredger for collection and direct pumping of dredged fill materials by 18" dia. or more cutter suction dredgers from the pre-selected river bed through pipe line to the proposed fill site in wet and liquefied condition. The dredged material will be placed at site directly and excess water will be removed out of the site. Spreading and compaction of fill material will be carried out in layers. The layer thickness shall be determined on the quality of dredged fill material. Each layer should be compacted to a minimum of 95% optimum density as defined by the Modified Proctor Test.

(b) Land development by carried earth/filling sand:

The responsibility of selecting proper location of collection of fill materials (such as earth/viti sand) will rest on the contractor, subject to the approval of the employer. The contractor shall obtain prior necessary permission from the concerned owner/authority paying royalties, all taxes, duties etc. as per prevailing Govt. / semi Govt. / Autonomous organization rule with the intimation to employer for collecting the required fill material. In this case mini suction dredger can be used to collect fill material from nearby river. The crops compensation resulting from the damage of crops during pipe line installation and any other activities shall be paid by the contractor and the cost deem to be included in the price. All fill shall be compacted in layers not exceeding 150mm deep to a minimum of 95% optimum density as defined by the Modified Proctor Test.

11.6.2 The quoted rates are inclusive of all the costs for supply of materials and hire charges for equipment and accessories etc. required to execute the works by the Contractor.

11.6.3 Before land filling, The Contractor has to construct necessary dyke/embankment for protection the developed land.

11.6.4 The rates are inclusive of all the royalties, taxes, VAT, octroi etc. to be paid to Govt. & semi-Govt. Organization or to any person for the earth borrowed from.

11.6.5 If the Contractor uses the land beyond the control of the Employer, the cost/hire charges, octroi etc. so required will be paid by the Contractor for carrying, laying & installation of equipment, tools & pipes etc. over that land.

11.6.6 The Contractor is responsible to obtain the permission/approval from the competent authority for the works as mentioned in clause no. 4 & 5 above.

11.6.7 The Contractor shall execute the pre-work measurements jointly with the representative of Employer for the area to be filled prior to start the land development work.

11.6.8 The Contractor, along with his bid shall furnish the detailed procedure of whole works with a list of manpower, tools & equipment required to execute the same. He shall, if the proposal is by dredged filling also show in the drawing location of the river bed to be dredged and the route of pipe lines from the dredging point to the filling area.

11.6.9 The Contractor shall clean and remove the unspecified & the unsuitable materials which do not mix with the earth at his own cost and responsibility.

The work may be increased or decreased as per site requirement and no extra price escalation by the contractor for such increase of work shall be entertained.

11.6.10 The Contractor will arrange the testing of the samples of the fill materials & compaction tests of developed areas by Laboratory approved by employer. Two samples (one at top and another at mid height of fill) should be carried out for compaction test on every 2500 square meter of field area and provided on suitable points. The cost of any or all such tests shall be borne by the Contractor.

11.6.11 The Contractor shall protect & maintain all the materials, equipment etc. against any theft or damage etc. at his own cost until the final executed works are handed over to the Employer.

11.6.12 After 30 days of completion of the land development work, the contractor will arrange the joint survey (Post-work measurement) along with the employer representative. The quantity of land development shall be calculated by the contractor and checked by the employer according to this joint post-work measurement and the pre-work measurement taken prior to start the work (as mentioned in clause no.7). The rates in the schedule are inclusive of all surveys/pre & post-work measurements.

11.6.13 The security of the equipment and materials used and the safety of the personnel engaged in the work shall be at the risk and responsibility of the Contractor.

11.7 Fire Extinguisher:

11.7.1 Control Room/Communication Room/Battery Rooms:

These rooms shall be protected by portable CO_2 fire extinguisher system. The system shall consist of all equipment required for directing the CO_2 gas discharge at a fire including, but not limited to, CO_2 cylinders and necessary piping, a flexible hose along with a jet nozzle. The effective reach of CO_2 gas jet release shall be sufficient to fight small fires that could develop in a control room area. Fire extinguishers shall be placed at strategic locations as per instruction of project engineer. The quantity of extinguisher at each new/up gradation AIS & GIS substation given in Table-1.

11.7.2 Outdoor Switchyard/Cable Room:

These areas shall be protected by portable dry type ABC powder fire extinguisher system. The system shall consist of all equipment required for directing the dry ABC powder discharge at a fire including, but not limited to, a wheel carriage(only for 15kg capacity) loaded with potable cylinders and

necessary piping and a flexible hose along with a jet nozzle & pressure gauge. The extinguisher material shall be non-explosive, non-hazardous, non-corrosive, and nontoxic. The effective reach of jet release shall be sufficient to fight small fires that could develop in an outdoor switchyard, cable room & store room area. Fire extinguishers shall be placed at strategic locations as per instruction of project engineer. In addition sand buckets also shall be provided with a metal frame for hanging buckets and shall be placed at locations directed by project engineer. The quantity of extinguisher at each new substation given in Table-1.

Table-1: The quantity of fire extinguisher shall be provided at each new substation as follows:

Sl No	Description	Quantity
1	CO_2 Type: 3kg 5kg	 5Nos. 5 Nos.
2	ABC dry powder type: 5kg 8kg 15kg(including wheel carriage)	 6 Nos. 4 Nos. 3 Nos.
3	Sand bucket with metal frame	One(1)set with 5 buckets

ANNEXURE-11.1

DETERMINATION OF DEPTH OF FIXITY, LATERAL DEFLECTIONAND MAXIMUM MOMENT OF LATERALLY LOADED PILES

11-1. DETERMINATION OF LATERAL DEFLECTION AT THE PILEHEAD AND DEPTH OF FIXITY

11.1.1 The Long flexible pile, fully or partially embedded, is treated as a cantilever fixed at some depth below the ground level (see Fig. 2).

11.1.2 Determine the depth of fixity and hence the equivalent length of the cantilever using the plots given in Fig. 2.

Where $T = (\frac{EI}{K_1})^{(\frac{1}{5})}$

(k_1 is a constants given below, E is the Young's modulus of the pile material in kg/cm2 and I is the moment of inertia of the pile cross-section in cm^4).

Note: Fig. 2 is valid for long flexible piles where the embedded length Le is ≥ 4R or 4T.

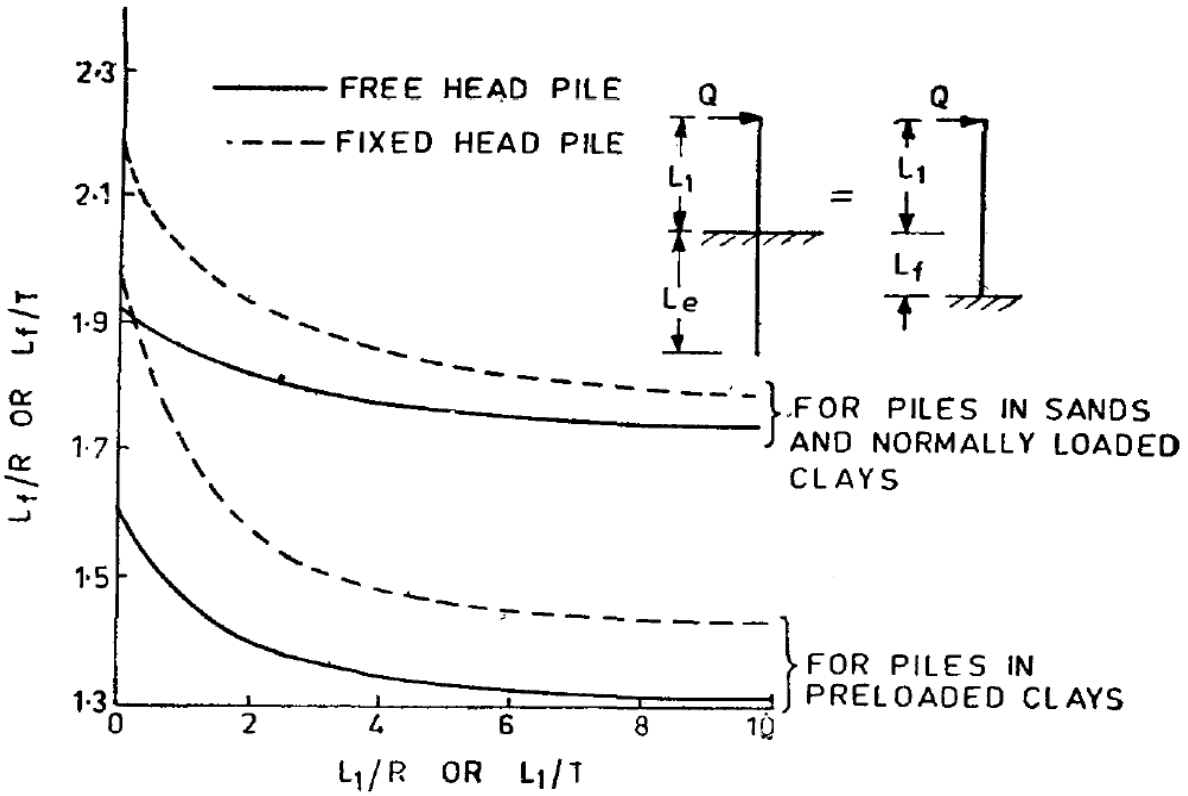


FIG. 2 DETERMINATION OF DEPTH FIXITY

K_1 is the constant of modulus of horizontal subgrade reaction, maximum value of k_1 may be considered as 0.525 Kg/cm^3.

11.1.3 Knowing the length of the equivalent cantilever the pile head deflection (Y) shall be computed using the following equations:

$$Y = \frac{Q(L_1 + L_f)^3}{3EI}$$

……for free head pile

$$= \frac{Q(L_1+L_f)^3}{12EI}$$

……..for fixed head pile

Here,
Y in cm
Q is the lateral load in kg

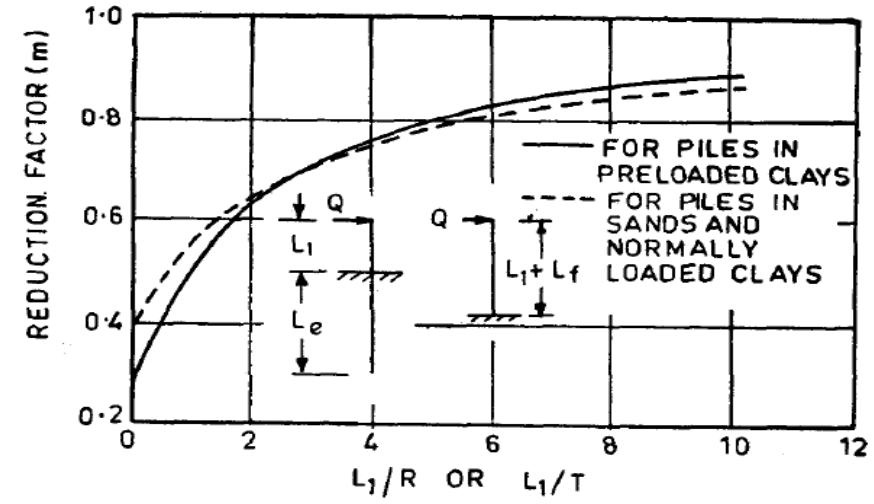
11.2. DETERMINATION OF MAXIMUM MOMENT IN THE PILE

11.2.1 The fixed end moment (MF) of the equivalent cantilever is higher than the actual maximum moment (M) of the pile. The actual maximum moment is obtained by multiplying the fixed end moment of the equivalent cantilever by a reduction factor, m given in Fig. 3. The fixed end moment of the equivalent cantilever is given by:

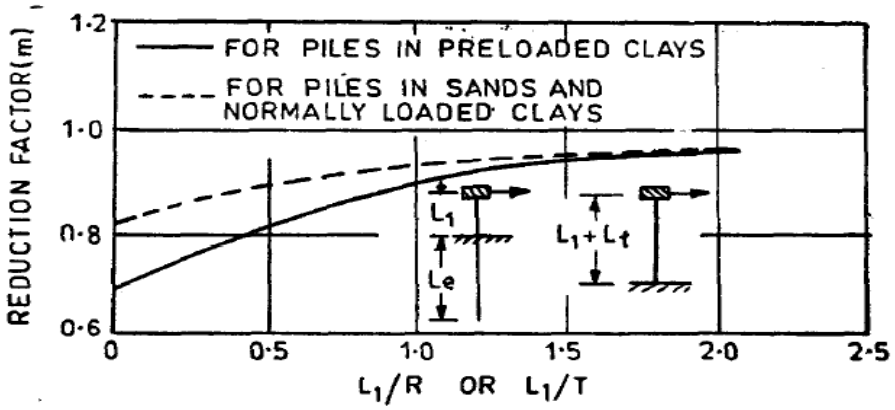
$M_f = Q(L_1$+Lf) ……for free head pile

$= \frac{Q(L_1+L_f)}{2}$ ……..for fixed head pile

The actual maximum moment (M) = m (M_f)



3A FOR FREE HEAD PILE



3B FOR FIXED HEAD PILE

FIG.,3 DETERMINATION OF REDUCTION FACTORS FOR COMPUTATION OF MAXIMUM MOMENT IN PILE

11.2.2 Reinforcement of upper section of pile should be provided upto 1.25x L_f depth

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 12

SUPPORTING STRUCTURES FOR OUTDOOR EQUIPMENT

SECTION 12

SUPPORTING STRUCTURES FOR OUTDOOR EQUIPMENT

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SECTION 12

SUPPORTING STRUCTURES FOR OUTDOOR EQUIPMENT

12.1 SCOPE

Where specified structures shall be provided under this contract for supporting the conductors, busbars, insulators, isolating switches, circuit breakers, current and voltage transformers, surge arresters, line traps, coupling capacitors, sealing ends or cable boxes and cables where necessary and other items of plant generally as shown on the relevant drawings. Facilities shall also be provided where specified for the termination of the incoming transmission lines.

All structure designs shall be such as to facilitate inspection, painting, maintenance, repairs and operation with the continuity of supply being the prime consideration.

12.2 STRUCTURE ARRANGEMENT

The arrangement of the high level structures supporting conductors and/or busbars shall be either lattice structures primarily composed of angle sections, or low visual impact A-frame type structures primarily composed of welded hollow or composite sections. Angle, hollow or composite sections shall be either steel or Aluminum as specified. For lattice structures a fully triangulated system of bracings shall preferably be adopted. For A-frame structures the primary connections between major components shall be bolted, for ease of transportation and erection.

Low level support structures shall be either lattice structures primarily composed of angle sections or 'moment' type structures primarily composed of welded hollow or composite sections.

The design and arrangement of supporting structures shall be subject to approval by the Engineer.

The type of arrangement of high level structures and acceptable materials for both high and low level structures shall be as specified in the Schedule of Technical Requirements.

12.3 DESIGN

12.3.1 General

The supporting structures shall be designed to ensure that the specified minimum phase, earth and section clearances are maintained under all conditions. Where applicable special attention shall be paid to the design of

the line termination structures to ensure minimum phase clearance is obtained for the complete range of angles of entry specified.

The strength and rigidity of structures shall be such that the alignment of the equipment which they carry shall not be affected by the static and dynamic loads to which the structures are subjected.

For the purposes of design all high level structures shall be considered as terminal structures. For multi-bay continuous structures, central columns shall be designed for the most onerous condition of adjacent bays being loaded or unloaded. For the purposes of design of line termination gantries, highest/maximum loaded gantry column should be identified from the line gantry layout and that same gantry should be designed for all line termination gantries.

The assumptions made in the overall structural design especially in the load transfer between the gantry beam and column shall be adequately reflected in the design and detailing of the beam-column connection.

12.3.2 Assumed Loading Combinations

The supporting structures shall be designed to resist the ultimate applied loading, determined in accordance with the following load combinations:

Load Combination 1 - Design Wind, Coincident Temperature, (Ice)

(a) The wind pressure specified in the Schedule of Technical Requirements Appendix 12 of this Section, applied to the projected area of all conductors and electrical equipment;

(b) The wind pressure specified in the Schedule of Technical Requirements applied to the projected area of all members of the windward face of structure;

(c) Where appropriate the conductor and/or earthwire tensions or busbar forces, including due allowance for both horizontal and vertical deviations /inclinations;

(d) Self weight of the equipment and structure;

(e) When stated in the Schedule of Technical Requirements the effects of the specified radial ice thickness shall be taken into account in the determination of the wind area of the conductor, earthwire, busbar, electrical equipment and the supporting structure, the conductor and earthwire tensions and the self-weight of the equipment and the structure.

The wind directions considered shall include transverse, longitudinal and if appropriate 45˚ to the major axis of the structure.

Load Combination 2 - Still Air, Short Circuit, Minimum Temperature or Maximum Operating Temperature

(a) Conductor and/or earthwire tensions or busbar forces including the dynamic affects calculated in accordance with IEC 865-1.

(b) Self weight of the equipment and structure;

The 'resultant spring constant' (s) of both supports in a single span of strained conductors shall be determined according to IEC guidelines for steel structures.

Load Combination 3 - Still Air, Seismic, Coincident Temperature (Ice)

(a) Conductor and/or earthwire tensions or busbar forces;

(b) Seismic forces;

(c) Self weight of the equipment and structure;

(d) When stated in the Schedule of Requirements the effects of the specified radial ice thickness.

Seismic forces shall be applied as a static horizontal force transversely and alternatively longitudinally to the major axis of the structure, and shall be equal in value to the seismic coefficient stated in the Schedule of Technical Particulars multiplied by the self-weight of the conductor, earthwire, busbar, electrical equipment and structure, and applied at the center of gravity of the equipment and structure as appropriate.

Load Combination 4 - Still Air, Erection, Coincident Temperature

(a) Conductor and/or earthwire tensions or busbar forces;

(b) Self weight of the equipment and structure.

For erection conditions any one complete phase conductor bundle or busbar or earthwire shall be assumed not to be erected in any one span.

12.3.3 Line Termination Structures

For details of the incoming transmission line phase conductor and earthwire details, and angles of entry reference should be made to the Schedule of

Technical Requirements & relevant drawings.

12.3.4 Partial Load Factors

The partial load factors to be applied to the loading combinations determined in accordance with Clause 12.3.2 shall be as specified in the Schedule of Technical Requirements.

12.3.5 Wind Loading

The reference wind pressure to be adopted for the design of the outdoor supporting structures shall be based upon the value specified in the Schedule of Technical Requirements. The reference wind pressure q_{ref} N/m2 at a height of 10m above ground level shall be subjected to variation for height and shape of the structure or equipment under consideration to give the total wind load.
The total wind load on the structure or equipment surface shall be determined from the expression:

The total wind load on the structure or equipment surface shall be determined from the expression:

$$F_w = q_{ref} \left[\frac{H}{10}\right]^{2\alpha} C_{shp} W_A$$

where Fw = The calculated total wind load on the structure or equipment:

- q_{ref} = reference wind pressure
- H = Height to top of the panel under consideration
- α = power law index
- Cshp= aerodynamic shape factor
- WA = windward face area of the structure or equipment

The aerodynamic shape factor Cshp shall be as specified:

Flexible conductors	1.0
Earth wires	1.2
Tubular busbars Re < 4.1×10^5	1.2 [1]
4.1 x 105< Re < 8.2 x 105	0.6
Support insulators, porcelain for apparatus or cap & pin insulator strings	1.2 [2]

Flat truss structures consisting of profiles	1.6
Square & rectangular lattice towers & supports consisting of profiles	2.8
Sharp edged structures & components other than above	2.0
Flat truss structures consisting of tubes	1.2
Square & rectangular lattice towers & supports consisting of tubes	2.1

Notes: [1] Re = Reynolds Number
[2] Based on external diameter of insulator.

12.3.6 Equipment and Conductor Terminations

All supporting structures shall be provided with such holes, bolts and fittings as may be necessary to accommodate insulators, isolating switches and other equipment provided under the Contract.

Where incoming transmission lines and/or conductors and/or earthwires are terminated at structures with tension sets, approved shackle or swivel attachments shall be provided. To facilitate maintenance and erection, additional attachment points shall be provided adjacent to the main termination attachment. The supply and connection of the incoming transmission line will be undertaken under a separate contract.

Structures required to support cable sealing ends shall be provided with arrangements for supporting the cables. Attachment holes for the connection of earthwire bonds shall be provided adjacent to the earthwire attachment point. Attachment holes for the connection of the substation earthing grid shall be provided on the vertical face of the structure, approximately 300mm above the top of concrete. Foundation holding-down bolts shall not be used for the attachment of earth connections.

12.3.7 Safety and Access Requirements

To facilitate safe inspection and maintenance all supporting structures which cannot be maintained from ground level shall be provided with climbing facilities, inter-circuit screens, guards etc in appropriate positions as agreed with the Engineer.

All members inclined at 40˚ or less to the horizontal shall be designed to resist a mid-point load of 1.5 kN, with no other loading being considered.

Where specified step bolts of an approved type shall be fitted to supporting structures at not more than 450 mm centres starting as near as practicable to the base and continuing to within 1m below the top of the structure. It shall be noted on the erection drawings that all step bolts are to be removed after construction for a distance of 2.0m above ground level. Adequate clearance shall be provided between the step bolts and any obstructions which might interfere with their use. Step bolts shall not be less than 16mm diameter, project not less than 150mm, and be fixed with nut, washer and nut.

Where specified ladders of an approved type generally in accordance with the requirements of BS 4211, 450mm wide and 350mm rung spacing shall be fitted to supporting structures. They shall be incorporated into the structure either integrally or separately. Where specified cage protection or fall arrest systems shall be fitted to the ladder. Means shall be provided to prevent unauthorised access of ladders.

Intercircuit screens shall be provided where necessary to prevent access between adjacent circuits on multi-bay structures. Inter-circuit screens shall be fabricated from a 50mm x 50mm mesh formed from 3mm diameter galvanised steel wire.

All structures shall be fitted with identification/notice plates as appropriate.

12.3.8 Structural Design

The allowable ultimate unit stresses used in the determination of the nominal member strength of supporting structures shall be based on the following:

Lattice steel structures	ANSI/ASCE 10-90
Steel A frame or moment structures	BS 5950
Aluminum structures	BS 8118: Part I

Partial factors to be applied to member nominal strength determined in accordance with the above stated codes shall be as specified in the Schedule of Technical Requirements. For ANSI/ASCE 10-90 the appropriate reference stress levels shall be based on the values specified in BS 5950.

The maximum allowable slenderness ratios shall not exceed the following:

	Steel /Aluminum
For column or support leg members, beam chords	120
For other load bearing compression members	200
For secondary (redundant bracings)	250
For tension only members	350

Members shall be of such shape, size and length to preclude damage or failure from vibration or stress reversal, including the detailing of connections.

Minimum member thickness and diameter of bolts shall be as specified in the Schedule of Technical Requirements

Holding down bolts shall be used to connect the structures to their foundations. The design of holding down bolts shall make adequate provision for combined axial and shear forces.

The nuts of all bolts attaching conductors, busbars or earthwire tension sets etc, shall be locked with a locknut. No screwed threads shall form part of a shearing plane between members, and bolts shall not project more than 10mm beyond the nut.

12.3.9 Lightning Mast

Lightning mast should be a steel structure which may be design as lattice / pole / pipe structure. Latest BNBC wind load shall be considered for design of lightning mast. Deflection should be within allowable limit of standard code and practices. Foundation should be design with the support reaction of the mast. In designing foundation bearing capacity, overturning capacity and sliding capacity must be checked.

12.3.10 Design Submissions

The Bidder shall submit all design calculations & drawings (with all soft/software copies) and method statements as required. All sets of calculations shall be complete, bound, properly titled and given a unique drawing number. An agreed system of identification of the structure design reference, fabrication drawings and substation general arrangement drawings shall be used.

Calculations shall contain a Design Information sheet, derivation of all applied loadings including sag and tension and dynamic tension calculations, the design load for each member group under the critical loading case, member size, slenderness ratio, allowable load, end connection detail and foundation load schedule. Codes or standard references should be quoted and where computer programs are used, a full explanation in the English language shall be provided to assist the Engineer's approval of the calculation.

12.4 MATERIALS

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate and shall be suitable for all usual fabrication processes including hot and cold working within the specified ranges. The Bidder must take due cognisance of the minimum ambient temperature, quality of steel, charpy impact value and stress relieving.

The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, lamination, segregation's and other defects. There shall be no rolling laps at toes of angles or rolled in mill scale.

Hot rolled steel plate 3mm thick or above shall be in accordance with the requirements of BS EN 10029.

Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190 and shall be threaded ISO Metric

Course Pitch to BS 3643: Part 2, Tolerance Class 7H/8g. Only one grade of steel shall be used per bolt diameter. Washers shall be in accordance with BS 4320 Grade E and BS 4464 Type B as appropriate.

Consumables used in metal arc welding shall be in accordance with the relevant standard.

All materials for aluminium. Structures shall be in accordance with BS 8118: Part 2.

12.5 WORKMANSHIP

The Bidder shall submit panel assembly (fabrication) drawings which shall show all materials in place, complete with all fabrication and connection

details. A complete tabulation listing all pieces, bolts, nuts, washers etc shall also be shown on the drawings. The Bidder shall make changes to the fabrication details which the Engineer determines necessary to make the finished structure conform to the requirements and intent of the specification.

The Bidder shall submit a detailed Method Statement of his proposed fabrication procedures including quality control procedures to ensure satisfactory assembly and erection, interchangeability of similar members, accuracy of dimensions, position and alignment of holes.

All welding shall be carried in accordance with BS 5135 for steel structures and BS 8118 Part 2 for aluminum structures. All members shall be stamped on before galvanizing or other protective coatings, using characters 10mm high and shall be clearly legible after galvanizing.

12.6 PROTECTIVE TREATMENT

Unless otherwise specified after fabrication, all structural steelwork, including bolts, nuts and washers shall be hot dipped galvanized to meet the requirements of BS 729. Bolt threads shall be cleaned of surplus spelter by spinning or brushing. Dies shall not be used for cleaning threads other than on nuts. Nuts shall be galvanized and tapped 0.4mm oversize and threads shall be oiled.

Excessively thick or brittle coatings due to high levels of silicon or phosphorous in steel, which may result in an increased risk of coating damage and/or other features that make the final product non-fit-for purpose shall be cause for rejection. Protective treatment for aluminum shall be in accordance with the requirements of BS 8118.

Galvanizing thickness and aluminum protection procedure shall be as specified in the Schedule of Technical Requirements

12.7 QUALITY CONTROL

12.7.1 General

Routine tests on raw materials and fabricated individual members shall be undertaken in accordance with BS EN 10025, BS EN 10210 and BS 8118 as appropriate.

All steel ex-mills or received from merchant's stock shall be marked to identify the cast or casts from which it was rolled in accordance with Section 9 of BS EN 10025 and Section 10 of BS 102 10, and shall be

covered by the appropriate (mill) certificate. The optional impact test BS EN 10210 option 1.6 for quality JO is required.

The material grades or alloy categories of individual pieces of steel/aluminum shall be capable of positive identification at all stages of the fabrication process.

Bolts and nuts shall be covered by the appropriate test certificate to prove compliance with BS 4190.

12.7.2 Welding

Unless specified to the contrary all structural welds shall be undertaken using approved welding procedures in accordance with BS EN 288. All welders shall be tested to the requirements of BS EN 287.

All welding shall be subject to a non-destructive testing (NDT) programme, which shall include visual, ultrasonic and magnetic particle testing as appropriate. Visual inspection shall be in accordance with BS 5289, ultrasonic to BS 3923 and magnetic particle to BS 6072. Acceptance criteria shall be in accordance with BS 5135, except for porosity and BS 8118: Part 2. All welds especially butt welds must be continuous to ensure a pickle-tight connection when galvanised.

The Bidder's NDT programme shall be submitted to the Engineer for approval prior to the commencement of fabrication.

12.7.3 Check Erection

Prototype structures shall be check erected in order to verify the accuracy of detailing and fabrication.

The degree of check erection shall be sufficient to verify not only the main structure, but all auxiliary steelwork. Sufficient blocking and support shall be provided to prevent distortion and overstressing of members to ensure proper fit. Assembly shall be accomplished without extraordinary effort to align bolt holes, or to force pieces into position. Bolt holes shall not be reamed or enlarged. Any damage to protective coatings during check erection if the check erection is undertaken on coated structures, shall be recoated at the fabricator's cost.

12.7.4 Galvanising

Tests on galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS 729.

12.7.5 Tolerances

The fabrication tolerances after galvanising for steel members, which are not to be considered cumulative shall be as follows:

(a) On linear dimensions of nominal sections as per BS 4, BS 4848, BS EN 10024, BS EN 10034 & BS EN 10056-2.

(b) On overall length of member ± 1mm

(c) On centres of holes ± 1mm

(d) On groups of holes ± 2mm

(e) On back-gauges ± 1mm

(f) On corresponding holes in opposite faces of a member ± 1mm

(g) On specified hole diameter on the punch side (in the black), ± 0.3%

Or when drilled 0mm

(h) Taper on the punched holes as measured between the specified hole diameter on the punch side and the hole diameter on the die's side (in the black) ± 1mm

(i) On specified bends, open and closed flanges ± 0.02%

The pennitted tolerances for straightness after galvanising shall not exceed an offset of 1: 1000.

Tolerances for aluminium structures shall be in accordance with BS 8118: **Part 2.**

12.8 ERECTION

The Bidder shall when requested provide the Engineer with a Method Statement detailing his proposed erection methods. Due cognisance shall be taken of the relevant parts of BS 5531 and current health and safety legislation.

All structural members stored on site shall be kept clear of the ground where possible. Contact with substances likely to attack the protective coatings shall be avoided and all members kept in a clean and tidy condition. Care shall be taken to prevent damage/deterioration of any protective coating during transportation, storage and erection. Unless otherwise agreed damaged members shall be replaced. The renovation of damaged areas of protective coatings shall be carried out using techniques agreed with the Engineer.

The Bidder shall ensure that the structures are not strained or damaged in any way during erection. Structures shall be erected vertically within a tolerance at the top, or the centre of the beam of 0.5% of the overall structure height before equipment installation or conductor/busbar stringing.

APPENDIX TO SECTION 12

Line	Description			
1.	Structure Arrangement [clause 12.2]			
	High Level		Lattice or A-Frame	
	Low Level		Lattice or Moment	
	Primary Material		Steel	
2.	**Load Combination 1** [clause 12.3.2]		Structures only	Structures Busbars etc.
	Wind pressure at above G.L. q_{ref}	kN/m^2	3.54	1.21
	Power Law factor	α	0	0.095
	Coincident temperature	˚C	5	
	Radial ice thickness	mm	0	
	Density of ice kg/m3		-	
	Load Combination 2			
	Minimum temperature	˚C	5	
	Maximum operating temperature	˚C	80	
	Load Combination 3			
	Seismic coefficient		0.1g	
	Coincident temperature	˚C	5	
3.	**Line Termination Structure** [clause 12.3.3]		**Phase**	**Earth wire**
	Conductor Designation & Type			
	132kV		Single ACSR Grosbeak	7 x 3.25 GSW
	230kV		Twin ACSR Mallard	7 x 4.0 GSW
	Number of sub-conductors (All of the above two shall be finalized during execution)		-	-
	Maximum working tension per Sub-conductor (132kV) kN (with maximum downlead span 100m)		7	4.5
	Maximum working tension per Sub-conductor (230kV) kN (with maximum downlead span 100m)		10	4.5
	Wind pressure kN/m2		1.40	1.76
	Radial ice thickness	mm	0	0
	Maximum angle of entry horizontal	deg.	45	45
	Vertical	deg.	0-30	0-30
	Low duty tension set wind area	m2	0.7	-
	Mass	kgs	100	-
4.	**Partial Load Factors** [clause 12.3.4]		**Steel**	**Aluminium**
	Load Combination 1		1.35	N/A
	2		1.0	N/A
	3		1.0	N/A
	4		1.5	1.5

Line	Description		
5.	**Safety and Access Requirements** [clause 12.3.7]	**High Level**	**Low Level**
	Step bolts	YES	NO
	Ladders:	YES	NO
	Cage protection	NO	NO
	Fall arrest system	NO	NO
6.	**Partial Material Factors** [clause 12.3.8]		
	Steel	0.85	
	Aluminum	-	
	Foundations	0.76	
7.	**Minimum Member Thickness** [clause 12.3.8]	**Steel**	**Aluminum**
	Main member mm	6.0	
	Other bracing members mm	5.0	
	Secondary (redundant) members mm	5.0	N/A
	Plates mm	6.0	
	Bolt diameters mm	16.0	
	Minimum thickness specified shall apply to both hot rolled and hollow sections		
	Minimum angle size mm	45x45x5	
8.	**Protective Treatment** [clause 12.6]		
	Galvanizing thickness µm	85	N/A
	Protection procedure	BS 729	No

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 13

LIGHTING, SMALL POWER, HEATING AND VENTILATION

SECTION 13

LIGHTING, SMALL POWER, HEATING AND VENTILATION

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SECTION 13

LIGHTING, SMALL POWER, HEATING AND VENTILATION

13.1 SCOPE

This section of the Specification includes for the interior and exterior lighting, small power, heating and ventilation systems.

Whenever practicable, fixtures shall be sourced locally. All lamps, fittings, plugs, sockets and general accessories of the same size and types shall be similar and interchangeable throughout the installation.

The lighting and small power equipment and installation shall comply with other sections of this Specification as appropriate.

All civil works associated with this section of the works shall be deemed to be included as part of the works in this section. No additional payments will be made for such requirements.

The requirements of this section of the works are subject to the Main Conditions and Specifications laid down in other sections of the Bid Document.

13.2 REFERENCES

British Standards

BS 7671 Code of Practice Regulations for Electrical Equipment in Buildings 15th Edition. Institution of Electrical Engineers.

BS 6004 Specification for PVC insulated cables (non armoured) for electric power and lighting

BS 6346 Specification for PVC insulated cables for electricity supply

BS 6500 Specification for insulated flexible cords and cables

BS 6121 Mechanical cable glands

BS EN 60947 Specification for control gear for voltages up to and including 1000V AC and 1200V DC

BS 4533 Luminaries

BS 3677 Specification for high pressure mercury vapour lamps

BS 1363 Specification for 13A fuse plugs and switched and unswitched socket outlets

BS 1362 Specification for general purpose fuse links for domestic and similar purposes (suitable for use in plugs)

BS 4568 Specification for steel conduit and fittings with metric threads of 150 form for electrical installation

BS 4066 Test on Electric cable under fire conditions.

BS 4434 Specification for safety aspects in the design construction and installation of refrigerating appliances and systems.

Institution of heating and ventilation Engineers Guide to current practice.

American Society of Heating Refrigeration and air conditioning Engineers

Recommendations

Heating and Ventilation Bidders Association of U.K. specification DW/ 121

BS 5970 Code of Practice for thermal insulation of pipework and equipment

BS 848 Fans for general purposes

BS 6540 Method of test for atmospheric dust spot efficiency and synthetic dust weight arrestance

BS 2871 Specification for copper and copper alloys: tubes

BS 1470 Specification for wrought aluminium and aluminium alloys for general engineering purposes, plate, sheet and strip

13.3 DEFECTS LIABILITY PERIOD

The Bidder shall be responsible for the efficient and good working of the installations comprising this section of the Specification for the agreed period as set out in the Specification document.

13.4 APPROVALS

The Bidder shall submit to the Engineer for approval copies of all his calculations forming the basis for the designs of the specified systems which shall be shown on the working drawings, also to be submitted for approval.

Any approvals shall not, however, relieve the Bidder of his contractual responsibilities which include obtaining local authority approvals for electrical wiring installations.

13.5 LIGHTING REQUIREMENTS

The lighting installations shall be designed to give the standard service illuminations and shall incorporate emergency lighting where indicated. Control rooms, relay rooms, telecommunications equipment rooms, offices and stores shall have the service illumination measured at 850 mm above finished floor level. All other areas shall have the service illumination measured at floor level.

The installations shall also meet the limiting glare index requirements as set out in the specified codes of practice. This section of work gives proposals for the types of lighting fittings to be used in the area, type of control to be employed, number of socket outlets and the types of mounting expected to be suitable for the respective areas. Where discharge and fluorescent light sources are to be used in areas containing rotating or reciprocating machinery, the fittings shall be allocated between the 3 phase and neutral in such a manner as to avoid stroboscopic effects. When 3 phase lighting installations are to be used, contactor switching controlled by pushbuttons located in the area to be illuminated is preferred.

In all rooms and corridors having two entrances the lighting installation shall have two way switching, the switches being located in appropriate positions adjacent to the entrances.

Emergency lighting shall be arranged to illuminate all stairways, exits and entrances and provide some illumination in operational areas within the control building and the

switchyard, e.g. circuit breaker and transformer locations.

Security lighting shall be installed around the perimeter walls illuminating the external area and shall be controlled from the gatehouse. The level of illumination for security lighting shall be measured at a distance of 3 metres outside the boundary wall.

13.6 SCHEDULE OF DESIGN REQUIREMENTS

The lighting system shall include provision for ease of erection, maintenance, cleaning, lamp replacement and future extension. Lamp replacement and maintenance should, unless otherwise approved, be possible without necessitating outages on main plant items.

Lighting apparatus shall be of top quality, designed to ensure satisfactory operation and service life under all variations of load, frequency and temperature. Industrial Grade LED lighting shall be used for road (approach road and internal road) and security lighting. Switchyard floodlighting shall use 500W LED lamps unless otherwise specified. 10% spare of each type of lighting shall be available.

Key to Abbreviations:

L	Local switches
S1, S2 etc.	Socket outlets or fused spur circuits
P.B	Push Button for remote control
T.S	Time switch control
C	Ceiling mounted
W	Wall mounted
P	Pole or earth mast mounted
M	Recessed modular mounting
D	Suspended
F	Flush installation
S	Surface installation
A	Automatic on mains failure.
BH	Behind ceiling diffuser.

13.7 CODING SYSTEMS

The Bidder shall, when preparing drawings showing the respective designs, use a code to identify each lighting fitting and socket outlet.

The code shall comprise letters and figures so compiled that the following information can be readily identified:

1. The lighting distribution board to which the fitting or socket outlet is connected.

2. If connected to the normal supplies or to the emergency DC supplies.

3. The circuit number and phase of the distribution board to which the fitting is connected.

4. The sequence of the fitting in a particular circuit.

13.8 DISTRIBUTION BOARDS

The distribution boards and all component parts shall be manufactured and tested in accordance with the latest standards and designed to suit the fault level of the transformers supplied. The Bidder shall demonstrate by calculation that this has been complied with.

Each, current carrying component shall be so designed that under continuous rated full load conditions in the climatic conditions at Site the maximum total temperatures permitted under the relevant Standards are not exceeded.

Each distribution board shall have a rustproof metal case of sheet steel with either a galvanised or enamelled finish. The colour of the enamel finish shall match the colour of other switchgear. The metal casing is to be provided with a number of knockouts or other approved form of cable entries, corresponding to the circuit capacity of the distribution board, and a suitable screened brass earthing stud.

Busbars, including neutral bar, shall be of high conductivity copper supported to withstand all normal and fault condition stresses.

All busbars, neutral bars and primary conductors are to be PVC sleeved in respective phase and neutral colours.

Distribution boards for exterior use shall be galvanised and weatherproof.

Neutral bars shall have an appropriate number of ways relative to the size of the board. They shall have a rating not less than that of the associated phase busbars.

The metal surface adjacent to any live part and all spaces between phases shall be protected by barriers of fireproof insulation material.

The distribution boards shall be either single pole or triple pole and neutral types and shall be equipped with means to provide overcurrent protection to each circuit. This protection may comprise an HRC fuse or a miniature circuit breaker, both of which shall be removable without exposing live connections.

Fuse bases and bridges, where used, shall be of an approved non hygroscopic insulation suitable for the receipt of HRC fuses.

Residual current circuit breakers shall be incorporated to protect all lighting circuits, socket outlets and supplies to appliances, etc. These shall comply with the requirements of the main electrical part of this Specification.

The current rating of the busbars in each distribution board is not to be less than the sum of maximum current rating of all outgoing circuits. The neutral connection for each circuit is to be direct to the neutral busbar.

Title labels of an approved type and inscriptions are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit lists shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit lists. The lists and cover are to be easily removable to permit circuit modifications.

The cables feeding the distribution boards will be connected directly to the incoming isolator or neutral bar as appropriate, unless otherwise indicated by the Specification.

Switchfuse units or isolators connected on the incoming side of a distribution board shall be mechanically attached to the board with solid copper electrical connections between the units. A suitable insulated barrier is to be supplied to prevent copper or carbon dust released under fault conditions passing from one unit to the other.

Distribution boards for use on the direct current system shall be double pole types equipped with adequately rated fuses.

Mixed capacity boards shall be employed and all contactors and time switches associated with the respective outgoing circuits shall be accommodated within the distribution board.

13.9 MINIATURE CIRCUIT BREAKERS

Miniature circuit breakers shall comply with the requirements of the main electrical part of this Specification. Typical Catalogue & Sizing Calculation of MCB shall be submitted for approval.

13.10 CABLES

Cables shall be XLPE insulated, single wire armoured and PVC sheathed overall and be manufactured and tested in accordance with the requirements of BS 5467, 600/1000V grade or equivalent. The outer sheath shall be coloured black and incorporate flame retardant characteristics to meet the requirements of BS 4066 and IEC 60332. Jute fillings will not be permitted. Cables shall comply with the requirements of the cable section of this Specification.

Flexible type cables for pendant cords and final connections to fixed apparatus are to be butyl or silicone rubber insulated and sheathed, manufactured and tested in accordance with the requirements of BS 6500, 300/500V or 300/300V grade as applicable.

The conductor is to comprise multistrands of 0.25 mm wire. The number of strands are to be not less than 30 and in all cases of a number suitable for the protection rating of the respective circuits.

All cables used for lighting and small power shall have copper conductors.

The Bidder is to select conductor sizes for the respective final circuits to meet the following conditions:

(a) That the minimum conductor size for lighting circuits is to be 1.5 mm2 and for socket outlets 2.5 mm2.

(b) That the size is to be adequate for the current to be carried as set out in the cable manufacturer's specification.

(c) That the size is sufficient to keep the voltage drop in the phase and neutral conductor to the farthest lighting or power point, under normal full load conditions, to within the final circuit limit specified in BS7671. Diversity will not be allowed.

13.11 CABLE TERMINATIONS

Terminations for cables shall comprise compression type glands with armour and bonding clamps to meet the requirements of Type E1 to BS 6121, or equivalent, and are to be designed to secure the armour wires, to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between

the cable outer sheath and gland and between the inner sheath and threaded fixing component. The glands are to project at least 10 mm above the gland plate to avoid moisture collecting in the cable crutch.

Earth bond terminal attachments are to be provided.

Terminations for rubber insulated cables are to comprise compression type glands where the function of the gland is to secure the outer sheath of the cable, in accordance with the requirements of Type A2 to BS 6121 or equivalent. A watertight seal is to be provided between the outer sheath and the gland.

Only one cable is to be terminated in each gland.

3.12 SEALING AND DRUMMING

Immediately after the works tests, both ends of all cables shall be sealed against the ingress of moisture, dirt and insects and the end projecting from the drum shall be adequately protected against mechanical damage during handling and shall be fitted with a pulling eye bonded to cores, sheath and armours.

13.13 CONDUIT

All wiring shall be installed in screwed heavy gauge welded steel conduit or heavy gauge PVC conduit, at the discretion of the Engineer. No conduit less than 20 mm diameter will be permitted.

Surface mounted - steel switchrooms, battery rooms, i.e.painted blockwork.

Flush mounted - PVC relay control rooms which have a decorative finish.

Steel conduits shall be manufactured in accordance with BS 4568, Part 1 or equivalent, heavy

gauge screwed and welded Class B and shall be galvanised. Conduit fittings are to be manufactured of good quality galvanised malleable cast iron and of small circular pattern to BS 4568, Part 2 or equivalent, with internally tapped spouts minimum length 21 mm. threaded to the correct length at intersections, tees, draw throughs and stopends.

Conduit fittings of PVC shall be of the plain bore pattern suitable for a pushon compression type jointand shall be sealed with a hard setting vinyl cement to prevent ingress of vermin, water, dust, etc. Inspection bends, solid or normal bends, elbows or tees are not to be used except with the approval of the Engineer.

Conduit runs shall, wherever possible, be concealed in ceilings, voids and walls, chases etc., and in rooms of secondary importance (with back outlet entries to switch boxes etc. especially on fair faced brickwork) otherwise the conduits shall be securely fixed to the surface of walls using heavy cast distance saddles. Where plastered finishes are called for, buried conduit systems shall be provided.

Where the system of wiring is concealed, the 'loopin' system of conduit shall be used and the 'loopingin' boxes shall conform to BS 31, Class B3.

A separate insulated earth conductor, coloured green and yellow, shall be run in PVC conduits and such facilities shall be provided at all terminal points.

Wherever the installation is specified as being flameproof, the conduit runs entering these areas shall have a barrier box inserted in the run immediately before the conduit passes

into the flameproof area. All conduit work inside the flameproof area shall be carried out with solid drawn galvanised conduit and all conduit fittings, sockets and accessories shall be galvanised and certified suitable for Group 1 hazard. At the completion of the wiring all machine faces on accessories shall be thoroughly cleaned and greased, prior to the screwing or bolting of all accessory cover plates into their final flameproof secure position.

The ends of all steel conduits shall be reamered to remove all burrs or sharp edges after the screw threads have been cut. All dirt, paint or oil on the screw threads, the conduit, sockets and accessories must be removed prior to erection. All conduits shall be swabbed through prior to installation of cables.

The ends of the conduit shall butt solidly in all couplings. Where they terminate in fuse, switches, distribution boards, adaptable boxes or non spouted switch boxes, they shall be connected thereto by means of smooth bore male brass bushes, compression washers and sockets. All exposed threads and all bends shall be painted with an aluminium spirit paint after erection.

All conduit and accessories, after being installed, shall be examined and all parts where the surface has been chipped or scratched shall be painted.

All conduits shall be kept 80 mm clear of water, gas and other services. Should this prove impracticable, then they shall be properly bonded by means of pipe clamps or other device ensuring mechanically sound, electrically continuous connection.

The method of installing PVC conduit and fittings shall conform strictly to the manufacturer's recommendation. These recommendations shall be submitted when seeking approval to the system proposed. In general the clauses dealing with steel conduit shall apply.

PVC tube not exceeding 25 mm in diameter shall be bent cold by means of the appropriate spring and the tube shall be saddled as quickly as possible after bending. When bending larger sizes of tube, the tube must be heated in an approved manner until it is pliable. A 90˚ bend shall have a radius of not less than five times the outside diameter of the tube.

Joints between conduits and conduit fittings shall be watertight and shall be made by means of a solvent adhesive as recommended by the manufacturer. Care shall be taken to ensure that the tube is clean and free from damp and grease and in particular dust, mould and oil.

The Bidder shall provide PVC tube ends and flexible covers to prevent ingress of concrete grout into the tubing and boxes.

All bends are to be made on Site to suit conditions and not more than two right angle bends will be permitted without the interposition of a draw box. No tees, elbows, sleeves, either of inspection or solid type, will be permitted. Generally long straight conduit runs from point to point shall have draw boxes installed at maximum intervals of 10 metres.

Deep boxes or extension rings on standard circular conduit boxes shall be used where necessary in order to bring the front of each box flush with the surface of the ceiling or wall. Where conduits are laid direct on the shuttering of the reinforced slab construction, conduit extension rings or deep boxes shall be used to raise the run of conduit to between the top and bottom reinforcing. Galvanised draw wires or other approved types shall be provided where conduits are not to be wired on completion or are to be wired by others.

All draw boxes and junction boxes shall be of ample size to permit the cables being drawn in and out. They shall be made of malleable iron or PVC approved type and the jointing

surface machined to ensure a dust tight joint. All circular boxes shall be provided with long spouts

internally threaded incorporating a shoulder for the proper butting of the conduit and a solid brass earth terminal tapped and screwed into the base of the box.

All conduit boxes shall be screwed on or in walls, ceilings etc. by countersunk wood screws of appropriate size. Holes in boxes shall be adequately countersunk to ensure the complete recession of the fixing screws. All inspection and drawin boxes shall be provided with covers fixed by round head brass screws.

Where surface conduit is specified, it shall be fixed by means of distance saddles and shall terminate in raised back pattern conduit boxes. Surface conduits shall not be bent or set to enter accessories, and where they turn through walls back outlet boxes shall be provided. Conduits shall be fixed at 1200 mm centres on vertical runs and 900 mm apart on horizontal runs.

Vertical conduit runs shall have saddles at 300 mm maximum from their points of emergence from floors or ceilings and the remaining saddles shall be fixed consistent with the requirements of spacing and appearance. Saddles shall be fixed on each side of every bend at 300 mm maximum from the point of intersection of the centre line conduit.

Conduits in ceiling cavities shall be supported independent of the suspended ceiling.

Where conduits cross expansion joints, the Bidder shall allow for the installation of expansion couplers at the positions of the expansion joint and at fight angles to it. He shall provide a bonding earth wire between each terminal fitted in the nearest conduit box each side of the coupler.

All flexible metallic tubing shall be galvanised watertight pattern fitted with sweated brass adaptors. External earth conductors, wrapped around the tubing, shall be provided.

Where conduits are laid in slab floor etc., the Bidder shall arrange for a competent person to be in attendance whilst the concrete pouting or screeding operation is being carried out, in order to avoid damage being caused to the conduits and also to ensure that the conduit work is in sound condition, properly and efficiently maintained during this installation period.

Particular care should be taken when setting out conduit runs to outlet points where they are to be fitted to furniture, kitchen fittings, etc. The Bidder shall ascertain exact details of the furniture and fittings construction in order that all conduit work shall wherever possible be concealed.

Conduits installed in chases of walls and floors shall be firmly secured by wrought iron pipe hooks or crampets and these fixings shall in themselves be sufficient to hold the conduits in place. Conduits installed in chases shall be painted with one coat of bitumastic paint before erection and a further coat shall be applied to all accessible surfaces including the hooks and the crampets after erection.

Recessed conduits buried in plaster shall permit a full 6mm. depth of cover over its entire length.

Provision shall be made for the tapping of condensed moisture.

Care shall be taken to prevent water, dirt or rubbish entering the conduit system during erection. Screwed metal caps or plugs shall be used for protecting open ends.

All conduit systems shall be erected completely with all conduit accessories connected. They shall then be offered for inspection and approval by the Engineer before any cables

are installed. Conduit boxes shall be fixed to the structure of the building independently of the conduit.

Where a conduit is exposed to different temperatures (either by surrounding air conditions or by virtue of the surrounding medium with which it is in contact) at any particular time, the section of the conduit at the higher temperature shall be isolated from the section at the lower temperature by means of a conduit box filled with an approved permanently plastic compound, after completion and testing of all wiring. Such a condition would arise if a conduit running in a warmed building is run to exterior points.

Where galvanised conduit is specified, all conduit, accessories, switch boxes and all associated apparatus used in the installation must also be galvanised. Galvanised conduit shall be used when mounted outside a building, installed in floor chases subject to dampness or accidental flooding, or buried in the ground. Conduit systems shall be weatherproof when erected outside a building. Exposed conduit threads shall be given a coat of zinc rich paint.

Conduit buried in the ground shall be wrapped with PVC self adhesive tape half lapped. The taping shall be extended for a distance of 150 mm beyond the point where the conduit emerges from the ground. Joints in galvanised conduit systems shall be made watertight using lead, aluminiurn paint and hemp and/or gaskets. The joints shall be partially screwed up before the paint and hemp are applied to maintain continuity.

All adaptable boxes shall be grey iron pattern unless otherwise specified. Where adaptable boxes are fitted flush, the cover plates shall be heavy gauge metal with 12 mm overlap on all sides. The internal depth of a box shall be not less than 40 mm.

Covers shall be secured by a screw at each comer and by additional screws as necessary to provide a maximum spacing of 300 mm between adjacent screws. Fixing screws shall be brass (round or cheese head).

Covers for boxes shall be of the same material as the box. For boxes mounted in weatherproof situations, the cover shall have a machined surface around the perimeter mating with a similar machined surface on the box and shall be complete with a gasket.

Every flush outlet box to which a luminaire pull cord switch or similar is to be fitted, shall be equipped with an approved type of break joint ring.

13.14 CABLE TRUNKING

Where trunking is specified it shall be constructed of 1.65 mm minimum thickness zinc coated mild steel or PVC and shall have a removable cover throughout its length with centre screw latch fixings. Trunking shall be rigidly fixed and supplied complete with purpose manufactured fittings, connectors, dividers, flanges, cable retaining clips, racks and copper earth continuity links. As an alternative, if approved, a proprietary brand of heavy duty plastic trunking may be acceptable. When submitting details for approval, full installation instructions as recommended by the manufacturer shall be included in the details.

All cables installed in trunking shall be labelled and identified in an approved manner. Clips shall be at 600 mm centres. Vertical cable trunking shall be fitted with cable pin racks arranged to avoid any strain on the cables.

All trunking shall be rust proofed, primed and painted and fixed at intervals not greater than 1,000 mm.

13.15 CABLE TRAYS

Cable trays, where required as part of the Contract supply, are to be the perforated galvanised sheet type.

Trays are to have upturned edges and be of a width suitable for the number of cables to be supported and are to be supplied with purpose made galvanised steel brackets suitable for mounting from the building structure. External cable trays shall be provided with covers.

Where site cutting of trays or support bracket steelwork is unavoidable, recutting bare steel shall be protected with two coats of an approved zinc rich paint immediately after cutting.

13.16 CABLE JOINTING

The Bidder shall be responsible for the sealing and jointing of all cables supplied and installed as part of this Section of the Contract. Straight jointing of cables is not permitted without the written consent of the Engineer.

13.17 CONTACTORS

Contactors shall comply with BS 5424 or equivalent and shall be of the electrically heldin types contained in heavy gauge sheet steel cases suitable for panel mounting. Each contactor shall be continuously rated and suitable for thirty inductive switching operations per hour.

13.18 SWITCHES AND PUSHBUTTONS

Switches shall be rated for 15 amps, shall be single pole types and be provided with an earth terminal.

Switches shall be one way, twoway or intermediate as required and, where mounted together, they shall be fitted in a common box.

Switches for use in areas designated for surface installation shall be quickmakequickbreak fixed grid industrial types mounted in galvanised malleable iron boxes with protected dolly and arranged where necessary for multigang switching.

Switches for use in areas designated for flush installation shall be microbreak types fixed to white plastic cover plates and mounted in galvanised steel flush type boxes.

Switchboxes shall be galvanised and fitted with screwed stainless steel front plates having a 6 mm overlap minimum for flush installations. They shall be suitably barriered and labelled where two phases are connected in the same box.

Switches mounted externally shall be of weatherproof pattern to IP55 level fitted with machined box and cover joint, brass operating handles, neoprene weathertight seals and external fixing feet.

Where DC emergency lighting circuits are to be switched, doublepole quick make, quick break switches with pillar type terminals and earthing straps shall be provided.

Switches shall be mounted 1.4 m above finished floor level.

Pushbutton switches shall either be flush or surface types contained in galvanised steel boxes and be single pole rated for 5 Amps. Pushbuttons shall be made of nonhygroscopic material, be nonswelling and so fitted as to avoid any possibility of sticking.

The terminals for all switches shall be adequate to accommodate 2 conductors, each a minimum of 1.5 mm^2 in area.

13.19 LIGHTING FITTINGS

Illustrations and/or samples of all lighting fittings which the Bidder proposes to purchase shall be submitted to the Engineer for approval before issuing any suborders.

Lighting fittings for interior and exterior use are to be manufactured and tested in accordance with the appropriate sections of BS 4533, IEC 60162 or equivalent and together with all components are to be suitable for service and operation in the tropical climate stated.

Each fitting is to be complete with all lamp holders, control gear, internal wiring, fused terminal block, earth terminal and reflectors or diffusers as specified. The design of each fitting is to be such as to minimise the effect of glare and such that the ingress of dust, flies and insects is prevented, where open type fittings are used it is to be impossible for insects to become lodged therein.

The control gear for use with fluorescent lamps is to be quick or resonant start type without starters. Chokes are to be impregnated and solidly filled with polyester resin, or other approved high melting compound, are to be manufactured to restrict the third harmonic content to less than 17% of the uncorrected current value, and are to be silent in operation.

The builtin ballast units shall comply with IEC 60082 and shall include radio interference suppressors and capacitors to correct the fitting power factor to a minimum of 0.85 lagging. Control gear noise levels shall be minimal.

Fittings shall be supplied complete with closed end vitreous enameled metal reflectors or totally enclosed opal plastic diffusers, which shall be fully interchangeable.

Dispersive reflector fittings suitable for mercury bulb fluorescent or tungsten filament lamps shall be of heavy gauge sheet steel finished vitreous enamel. They shall be fitted with antivibrators and arranged for conduit box mounting, direct or pendant, on galvanised ball and socket dome type lids.

Bulkhead fittings shall have cast bases tapped for conduit entry, hinged bezels, heat resisting prismatic glasses fitted with neoprene gaskets and porcelain lampholders. Circuit cable shall not be connected direct to bulkhead fittings but shall terminate in a fixed base connector mounted in a conduit box adjacent to the fitting. Final connections to each fitting shall be carried out with silicone rubber covered cable. All bulkhead fittings shall be watertight pattern.

Internal connections are to comprise stranded conductors not less than 0.75 MM2 covered with heat resistant insulation to the requirements of BS 6500 or equivalent. All internal wiring is to be adequately cleated to the fitting casing with an approved form of cleat. The finish of fittings for interior use is to be impervious to deterioration by atmospheric reaction. Fittings for exterior use shall have a vitreous enamel, natural aluminium or galvanised finish according to the manufacturer's standard product.

Lamp holders for tungsten lamps up to 150 watts shall be brass or porcelain BC type and

for higher ratings shall be ES or GES type according to size. Fittings for housing tungsten lamps exceeding 150 watts rating are to be provided with an approved method of dissipating heat from the lamp cap and terminal housing.

Lamp holders as applicable are to be suitable for the lamp specified.

Lighting fittings are to be of the type description as generally set out in the schedule appended to this section of the Specification. The type references used are to be repeated in the Schedules and on the drawings.

13.20 LAMPS

The Contract includes the supply and erection of all lamps and tubes necessary to complete the installation.

Fluorescent lamps shall be manufactured and tested in accordance with BS1853, IEC 60081 or equivalent, shall be bipin types and shall have colour rendering values of X = 0.335 and Y= 0.342 (i.e., Colour 2) on the CIE chromaticity scale.

Tungsten lamps shall be manufactured and tested in accordance with BS 161 or equivalent and shall be bayonet cap for lamps up to and including 100 watts. Lamps rated for 150 watts and higher shall have edison screw caps. Low wattage lamps used in exit signs and emergency lighting units may be small or miniature edison screw.

Discharge lamps shall be manufactured and tested in accordance with BS 3677 or equivalent. Mercury vapour lamps shall be fluorescent types having a 10% red ratio colour correction, whenever used.

13.21 SOCKET OUTLETS AND FUSED SPUR OUTLETS

Each socket outlet shall comply with the requirements of the BS 1363 or equivalent and shall be the interlocked shuttered and switched types arranged for surface or flush mounting in single or multi gang units as appropriate.

Each fused spur outlet shall be equipped with double pole isolator, a fuse to BS 1362 or equivalent and where required front entry for flexible connection.

Each socket outlet and fused spur outlet shall be equipped with a galvanised metal box with earth terminal.

Each group of five socket outlets is to be provided with a matching fused plug top.

All socket outlets for exterior use shall be galvanised and weather proof and be equipped with screwed dustproofed cap attached to the socket by means of a chain.

13.22 TIME SWITCHES

Time switches for use with lighting systems shall be the synchronous motor wound types protected by a suitably rated fuse for 230 volts operation with a nine hour reserve spring and are to be fitted with a twentyfour hour hand set dial, two "off" and two "on" levers and manual operation pushbutton. The main contacts shall be rated for 20 Amps on a 230 Volt 50 Hz AC supply.

Time switches shall be suitable for mounting in the distribution boards supplying the circuits to be controlled.

13.23 POLES

Lighting poles shall be tapered, of hot dip galvanised steel with bituminous preservative inside and outside at the base and shall be approved by the Engineer.

Each pole shall be equipped with a base section compartment of 470 mm by 150 mm to house an inspection trap, lockable door, fused cutout, cable entry and terminations for both the incoming and outgoing power cables and secondary cables feeding the light sources.

Poles for substation lighting shall support the floodlights at 11m above ground level and poles for access roadway lights shall support the lanterns at 4.5m above ground level.

The Bidder shall ensure each pole is provided with foundations suitable for the ground conditions occurring at each Site.

13.24 INTERIOR INSTALLATIONS

Wiring for the lighting and socket outlet installations shall comprise PVC cables drawn into conduits attached to walls, structural or roof steelwork or ceilings as appropriate. (See Clauses 13.13 & 13.14).

Surface and flush type installations are required according to the particular area as indicated in the schedule appended to this section.

In areas where flush type installations are indicated the wiring shall be drawn into conduits buried under wall finishes or concealed above ceilings as appropriate.

All fixings shall be of a type approved by the Engineer and all metalwork used shall be galvanised. Fixings to structural steelwork shall be with purpose made brackets or clamps; the drilling of structural steelwork will not be permitted.

Cleats with two screw fixings shall be used for supporting conduits at not greater than 2m intervals.

All switchboxes, socket outlet boxes and items of a similar type shall be fixed with two screws or bolts.

Switches and pushbuttons for lighting circuits shall be mounted at 1400 mm above finished floor level. Socket outlets shall be mounted 500 m above finished floor level but those for use with workshop benches shall be mounted 150 mm clear of the bench working surface.

Lighting fittings shall be attached to ceilings, walls, trunking or roof steelwork or suspended therefrom as appropriate.

Where fittings are to be suspended, rod type suspension units shall be employed.

Final connections to all suspended lighting fittings shall be with heat resistant flexible cable terminated in porcelain clad connectors in the ceiling or junction box which shall also terminate the main circuit cable. The cable length shall be such that the suspension unit supports the full weight of the lighting fittings.

Where recessed type lighting fittings are to be installed suspension units shall be used to prevent the weight of the fittings being applied to the suspended ceiling. It shall be possible to carry out maintenance from the underside of the fitting without disturbing the false ceiling. To facilitate this need the final connection to each fitting shall be with heat

resistant flexible cable from a plug in type ceiling rose mounted above the false ceiling.

All cables not contained within conduit for their whole route shall be terminated with a cable gland.

Where lighting fittings are mounted direct on walls or ceilings, the main circuit cables may be connected into the fitting terminal block. Where terminal blocks do not exist within the lighting fitting, flexible heat resistant cable shall be used connected to a separate junction box.

Earth continuity shall be maintained throughout the entire wiring installation with separate insulated earth continuity conductors of adequate crosssection ultimately connected to a common earth terminal at the respective distribution board.

Within the interior installation adequate provision shall be made for connection to small ventilating fans, which are not energised from the central air conditioning control and starter panel.

Each and every trunking route shall be bonded across all joints with external copper bonding links supplied for the purpose.

13.25 EXTERIOR INSTALLATION

Exterior substation lighting fittings shall be attached to substation walls at high level or pole mounted as appropriate. Security lighting round the perimeter wall/fence is to be provided.

When locating the floodlights for the switchyard lighting, the Bidder shall ensure that all floodlights are outside safety clearance for the high voltage switchgear at the particular location.

Cables to exterior lighting shall be laid direct in ground, laid in concrete trenches or cleated to buildings structures as appropriate to the route requirement. The cables shall be terminated at a cutout located at the base of each support. Wiring between the cutout and the control gear or lantern shall be with multicore cable run within poles or with cable drawn into galvanised steel conduit attached to the supporting structure.

13.26 EMERGENCY LIGHTING

Emergency lighting shall comprise lighting fittings of the types indicated in the schedule appended to this section of the Specification.

The system shall be so arranged that on failure of the normal a.c. supplies to the lighting installation the emergency lighting system will automatically be switched on. Other than those of the "on demand" type, all emergency lighting shall be switched "off" 5 minutes after restoration of normal supplies. Each emergency lighting unit shall have a minimum 3 hour rating.

Sufficient fittings of Type E3 shall be provided in each room to enable the rooms and building to be evacuated safely.

In addition, in designated working areas emergency manually switched lighting, to give not less than 30 lux, shall be provided utilising type E4 fittings. Switches shall be labelled to the approval of the Engineer.

The security lighting scheme shall illuminate the area to 6 metres inside the perimeter

wall to the lighting level specified.

13.27 TELEPHONE SYSTEM

A complete conduit/duct system shall be provided throughout the building to enable the telephone cables to be run to the proposed extension points. This includes telephone wiring to operators' desks and office in the control building.

Telephone instruments, the PABX and connections to PTT exchange lines shall be carried out by other Bidder.

13.28 SCHEDULE OF LIGHTING FITTINGS AND SOCKET OUTLETS

All lighting schemes are to utilise fittings and lamp types which are available locally in Bangladesh to ensure that replacements are readily acceptable.

Lighting fittings described in this Schedule shall also meet the general requirements of the Clause for Lighting Fittings of this Specification.

TYPE F1 Shall indicate a basic channel complete with control gear and lamp holders for one fluorescent lamp, equipped with an open ended metal reflector having upward light slots.

TYPE F2 Shall indicate a fitting which shall comply generally with the description for Type Fl but be equipped for use with two lamps.

TYPE F3 Shall indicate a recessed modular fitting suitable for mounting in a suspended ceiling and equipped with a clear prismatic controller. The metalwork and trim are to comprise a rigid welded unit so arranged as to be invisible when erected complete with controller. The fitting is to be equipped with a prewired removable gear tray and adjusting facilities to enable levelling relative to the ceiling to be carried out after erection. The assembly is to be complete with control gear and lampholders for one 1500 mm long 65 watt fluorescent lamp.

TYPE F4 Shall indicate a fitting which shall generally comply with the description F3 but with an open type grid diffuser.

TYPE F5 Shall indicate a dusttight, weatherproof and vapour resistant fitting, having a grey polyester fibre glass reinforced chassis containing the control gear and having lampholders for one 1500 fluorescent lamp. The fitting shall be complete with a vacuum formed acrylic diffuser which is secured to the body with injection moulded toggles and sealed with a neoprene gasket.

TYPE F6 Shall indicate a weatherproof bulkhead fitting with a cast aluminium base and vandal resistant diffuser equipped with control gear and lampholders for two fluorescent lamps.

TYPE E1 Shall indicate a selfcontained, selfsustained (normally off) emergency lighting unit, complete with integral batteries and control gear, with the words "EXIT" in white letters on red background in English and Arabic. It shall be energised from the batteries under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

TYPE E2 Shall indicate a selfcontained, selfsustained (normally off) wall mounted emergency lighting unit comprising a pilot light and two 100 watt spotlights complete with integral batteries and control gear. The pilot light shall be energised under mains failure

conditions with manual "on demand" switches for the spotlights. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

TYPE E3 Shall indicate a selfcontained, selfsustained (normally off) wall or ceiling mounted emergency lighting unit complete with integral batteries and control gear. The lamps shall be energised under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

TYPE E4 Shall indicate a 110V DC wall or ceiling mounted emergency lighting unit which shall be manually switched and be similar to type E3.

TYPE H1 Shall indicate forward throw floodlight fitting comprising a sheet steel vitreous enamelled or spun aluminium reflector housing a 500 Watt Industrial Grade LED lamp. The fittings to be complete with wall mounting bracket.

TYPE H2 Shall indicate a semi cutoff roadway and perimeter security lantern with housing manufactured from a one piece LM6 aluminium alloy casting enamelled white internally and equipped with reflector bowl of heat resisting glass, all suitable for housing the lampholder and control gear for one 150 Watt sodium vapour lamp. The fitting to be equipped with pole arm suitable to give an outreach of 1 metre.

TYPE S1 Shall indicate a 13 Amp single or double gang flush mounted switched socket outlet.

TYPE S2 Shall indicate a 13 Amp single or double gang surface mounted switched socket outlet.

TYPE S3 Shall indicate an ironclad one gang heavy duty 4 pole interlocked switched socket outlet with scraping earth connection suitable for use on a 400V 3 phase 4 wire 50 Hz for 125A. Each socket is to be supplied complete with cable box with 2 glands, suitable for terminating a PVCWPVC cable and shall be fitted with a screwed dustproof cap attached to the top of the socket by means of a chain. Matching plugs to be provided in each socket.

TYPES4 Shall indicate a 15 amp 3 phase 4 wire switched socket outlet with plug flush mounted.

13.29 SCHEDULE OF LIGHTING REQUIREMENTS

13.29.1 Control Building

Location	Average Service Illuminance (Lux)		Glare Index
(a)	Control /Relay /Operator Room	250	25
(b)	Behind panels	100	
(c)	In charge Office	400	20
(d)	Battery Room	200	
(e)	Toilet	100	
(f)	Corridors, Stairs	80	20

The height of working plane should be 0.6-0.9 meter.

13.29.2 Outdoor Areas

(a)	Switchyard Floodlighting	20
(b)	Transformer Compounds	120
(c)	Roadway Lighting	20
(d)	Perimeter Wall Security	10
(e)	Control Building Exterior	15

13.30 AIR CONDITIONING AND VENTILATION

13.30.1 Scope of Work

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the heating and ventilating systems for the control building.

All heating and ventilating systems shall be fully automatic in operation and shall be capable of maintaining internal conditions within the bands of temperature and humidity specified hereafter. The substations are normally manned and allowance shall be made for at least four persons on site in the design.

13.30.2 Heating

Electrical heating shall be provided for each room of the building. Except for the battery room, the heating shall comprise of 1500mm long tubular heaters with a load of 60 watts/foot (300mm) which shall be mounted in double tier banks. Electric heaters shall be fitted with bright plate safety guards affording full portection to the heating tubes. The Bidder shall assess the thermal performance of the building and ensure that the sizes of units are adequate to maintain internal temperatures of 5° C when the external temperature is -3°C, measured 1200mm above finished floor level out of an air stream.

The heaters in each room shall be controlled by contactors which have thermostats connected into the coil circuit. Thermostats shall be located in each room and have a maximum cut-off temperature of 17° C.

Each heater bank shall be equipped with a local isolator. The lower tubular heater shall be mounted at 500mm above finished floor level.

13.30.3 Air Conditioning

The following areas shall be air conditioned.

Operation Room

Switchyard Control/Relay room

Communication/SCADA/PLC room

Office/record room

Air conditioning shall be provided in the form of Air Cooled Split System Air Handling Units. The systems shall handle predominantly recirculated air with a controlled quantity of fresh air introduced either at each unit or independently via a separate supply and extract system. Supply air distribution ducts for the Control/Relay room shall be located in the false ceiling serving supply diffusers. Return (recirculated) air shall be drawn in

through the front of each unit.

The cooling medium for the split System Air Handling Units shall be direct expansion provided by air cooled refrigeration condensing units located on the roof of the building or wall mounted on building exterior, and interconnected by refrigerant pipework to multi circuit direct expansion cooling coils.

Air conditioning system shall be thermostatically controlled to maintain internal conditions under continuous operation within the limits stated. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

The air-conditioning system shall be 100% redundant, rugged, reliable, maintenance free, industrial type and designed for long life. Necessary temperature transducer (along with all accessories) shall be provided in the panel room to monitor the temperature inside the panel room and output of transducer shall be integrated to SAS.

The air-conditioning system shall be designed for continuous or 24/7 operation.

13.30.4 Mechanical Ventilation

Supply and extract ventilation shall be provided to serve the following areas:

Switchgear room

Battery Rooms

Toilets (Extract only)

Cable basement

Supply air handling plants shall consist of a sand trap fresh air intake louvre, insect screen, pre-filter, bag filter, electric air heater battery, fan and distribution ductwork.

The air intake shall not face the prevailing wind.

Extract ventilation shall be provided by means of wall mounting fans, roof extract units or ducted systems with louvred discharges to atmosphere. Individual extract fans shall be provided for Battery room and toilets.

Extract fans for battery room shall be explosion proof, corrosion resistant throughout, with a 4 mm PVC lining.

13.30.5 Basis for Design

(a) External Design Conditions

The external conditions for the calculation of duties for the mechnaical services shall be with mean monthly, maximum and minimum values as below:

Maximum ambient shade temperature		42 ^{o}C
Minimum ambient shade temperature		4 ^{o}C
Maximum daily average temperature		35 ^{o}C
Maximum annual temperature		25 ^{o}C
Relative humidity	- maximum	100%
- minimum	80%	

Solar radiation 100mW/sq.m

All plant and equipment installed externally, or which can be affected by external condition shall be capable of withstanding without damage or deterioration the effects of solar radiation, rain, wind, dust, sand storms or other weather phenomena prevalent in the area in which particular building is located.

(b) Internal Design Conditions

Air conditioning systems shall be capable of maintaining internal conditions in all air conditioned areas within the following bands or, if necessary for the satisfactory operation of the equipment housed, more stringent requirements:

For substations 22+4 ^{o}C DB

40 to 70% R.H.

The following air change rates/hour shall be provided in mechanically ventilated area:

Switchgear Rooms	10
Battery Rooms	10
Toilets	12 (Extract only)
Cable basement.	6
Other general areas	4

All air conditioning and ventilating systems shall be designed for continuous or 24/7 operation with n-1 contingency i.e. failure of one device shall not reduce the required/designed Cooling & ventilation. Plant shall be arranged to facilitate maintenance and future replacement of equipment. Such provision shall be made available that, the Air Conditioning Device shall be remotely monitored & controlled.

The Bidder shall calculate heat gains and losses under the specified conditions for each part of each building, taking into account solar radiation, thermal transmittance through roofs, walls, floors and windows, fresh air requirements, heat emission from installed electrical equipment and lighting, personnel, infiltration and any other sources. The Bidder shall be responsible for determining the heat transfer coefficients for all materials used in building construction. The full Air Conditioning Design shall be submitted to the Employer for review and approval. In the event of any change in materials. design or method of building construction, the Bidder shall at all times be responsible for rechecking the design of all systems to ensure that they are capable of meeting the specified design requirements and taken approval from the Employer.

13.30.6 Air Cooled Condensing Units

The cooling medium for the air conditioning shall be direct expansion refrigeration provided by air cooled condensing units located externally.

The condensing units shall be of the fully packaged type requiring only site connection of refrigeration pipework, , isolated electrical supply and input from the control system.

The individual item of refrigerant equipment shall be matched such that the required performance of the evaporator is achieved concurrently with the satisfactory operation of the compressor and adequate heat rejection at the condenser. Each system as a whole shall maintain the correct duty at the design ambient and operate at the maximum ambient

conditions stated without exceeding the safe operational limits of any individual item of equipment and without causing any safety device to operate.

All electrical equipment, control, magnetic coils and solenoids shall be manufactured specifically for operation at the electrical characteristics specified herein and such items designed for any other characteristics shall not be used.

Air cooled condensing units and air handling units that are inter-connected on site with refrigerant piping shall all be supplied by the same manufacturer.

The casings of the condensing unit shall be weatherproof and shall incorporate adequate access and inspection panels secured in place by rustproof fasteners.

The whole of the casing shall be treated for corrosion and weather resistance and non galvanised mild steel shall not be used (even if painted).. The unit shall be finished in not less than two coats of weather resistant finish, such as baked enamel of a light reflective colour.

The access panels shall be adequately sized for the service and removal of all working parts of l the unit. All panels shall be stiffened and supported to prevent flexing and drumming.

Electrical equipment shall be contained in a fully weatherproof enclosure with internal division between the power connections and equipment and the control connections and equipment.

13.30.7 Refrigeration Systems

(A) Liquid lines shall be insulated where they are in direct sunlight or where they pass though non-air conditioned areas.

Suction lines shall be insulated over their entire length.

All insulation to refrigeration pipework shall be flexible closed cell l foam phenolic rubber type with a temperature range of -40°C to +105°C and having a thermal conductivity of 0.0375 w/m °C at 2l °C and a water vapour transmission of less than 6.0 ng/Ns.

The thickness of insulation shall be in accordance with the following tables:-

i) Suction Lines

Location	Insulation thickness for O.D. Pipe Sizes Range	
	6-10mm	12-22mm
Exposed to weather	13mm	19mm
In air conditioned spaces	9mm	19mm
In non-air conditioned spaces	9mm	9mm

ii) Liquid Lines

Exposed to weather and in non-air conditioned spaces	9mm	9mm

(b) The refrigerant used shall conform to BS 4334 Group 1 or equivalent and shall be non explosive, non-combustive, non-toxic and non-irritating.

Packaged air conditioning plant items requiring interconnection with refrigeration piping on site shall be leak tested by the manufacturers and delivered to site with a holding charge of refrigerant.

13.30.8 Console Air Conditioning Units

Console model room air conditioners shall be of the slim-line pattern and complete with 4-way adjustable grilles, heavy gauge zinc coated stove enamelled sheet steel casing with single or two colour decorative finish. Electrical-heaters shall not be fitted.

The casing and position shall be such as to protrude not more than 250 mm into the air-conditioned space and no external projection beyond the building line will be permitted other than the fixing of the condenser cooling air grille.

The units shall be extremely quiet ill operation, the noise level not being higher than 30 dB. All sections of the casing shall be acoustically and thermally insulated.

Compressors shall be of the fully hermetic type, fitted with resilient mountings and complete with thermal overload protection and starting relays.

Evaporators shall be manufactured of' copper tube with copper or aluminum fins mechanically bonded. The evaporator fan shall be of double inlet, double width type and

complete with continuously rated totally enclosed electric motor.

Filters shall be of the washable type, suitably positioned for easy access for cleaning.

Automatic control by means of an integral thermostat shall be provided, together with the safety control to prevent excessive cooling.

Motors shall be air cooled and units shall be complete with internally mounted condenser cooling fans with totally enclosed motors.

Fresh air shall be introduced separately by means of a central fresh air plant, where these units are proposed to serve individual offices in a building.

Units shall be supplied as a whole and be suitable for easy removal and re-positioning should this be desired at a later date.

13.30.9 Ductwork

All sheet metal ducting shall be manufactured and installed in accordance with the Institution of Heating arid Ventilation Engineers Guide to Current Practice Section B 16, the American Society of Heating, Refrigeration and Air Conditioning Engineers, or the Heating and Ventilating Bidders Association of United Kingdom Specification DW/142 or equivalent international standards for sheet metal ductwork for low velocity low pressure air system with air velocity of up to 10 m/s.

Ail ductwork and fittings serving hazardous areas, such as battery rooms where corrosive fumes are expected, shall be of rigid PVC materials.

13.30.10 Condensate Drains

Provision shall be made for condensate to be passed into the rainwater drainage system. Condensate drains must be routed directly into the drainage system or individual soakaways. Pipes discharging onto substation or building brick paving will not be permitted.

13.30.11 Extract Ventilation Units

This clause covers fan powered extract ventilation units for mounting in walls and windows, on roofs and in plant rooms.

Extract units shall incorporate propeller. aerofoil, axial, centrifugal or hybrid type fans

which shall be constructed in accordance with the relevant sections of this Specification.

Roof units shall comprise a galvanised sheet steel base suitable for use as a weathering skirt, a mild steel fan/motor mounting frame and a spun aluminium cowl.. The sheet steel base shall be constructed to support the fan/motor without distortion and where the fan is belt driven shall incorporate a rigid subframe for motor mounting. Fans shall be diaphragm mounted or fitted with a cylindrical casing designed for removal from the unit from inside or outside the building without disturbing the weathering skirt or cowl fixings. The cowl shall be weatherproofed and shall be hinge mounted to provide complete access to the fad/motor.

Lubricating points shall be extended to a convenient access point.

Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

13.30.12 Air Filters

All filter media hall be properly bonded and protected against filter fibre or particle migration. The direction of air flow shall be clearly marked on all filter panels and on installation frames.

Access to filters shall be through removal panels fitted with quick release fasteners and rubber sealing gaskets.

Each disposable panel filter system shall be provided with 4 complete spare sets for use during the commissioning period. These sets shall be in addition to any filter cells supplied as spares in accordance wit11 the general clauses of this specifications.

Filter performance shall, unless otherwise noted, be taken to mean the Overall Gravometric Efficiency against BS 6540:Part I Duct Test or equivalent.

Filter media of all types and sizes shall be supported in rigid peripheral frames with internal or external wire support of the media to ensure that the media shall not collapse under air flow. The

holding frames shall incorporate accurately sized channel sections to provide a good fitting for the filters.

The type of washable and/or disposal panel filters shall be subject to the Engineer's approval.

13.30.13 Grilles and Louvres

Grilles shall be of aluminum construction and shall be fixed by means of subframe with spring clips or screw fixings.

The corners of front flanges of grilles and subframes shall be mitred and jointed to produce a clean unbroken appearance and visible aluminum sections shall be free from extrusion marks.

Front flanges shall be at least 30mm wide and shall incorporate a lip of at least 4.5 mm and a felt gasket. Blades shall be fixed at even centers with intermediate mullions giving support for blades of more than 550 mm long. Grille finish shall be anodised natural aluminium colour except where otherwise indicated.

All grilles shall be fitted with an opened blade damper for regulation purposes and shall be fitted with acoustically lined inlet plenums where necessary in order to comply with the acoustic limits of this Specification.

Outdoor air louvres shall be of all extruded aluminium construction fitted with opposed blade dampers in the connected ducting where necessary for air flow regulation, Movable blade louvres shall not be used.

Louvres shall be weatherproof and shall incorporate an aluminium wire mesh screen on the inside surface.

The dimensions of louvres for mounting in the building structure shall suit the concrete block or brick modules and shall be fixed to a hardwood frame.

13.30.14 Control Equipment

Each item of shall be provided with local isolation and/or emergency stop buttons to facilitate maintenance, inspection and emergency operation.

The control system shall be of the electronic type, capable of providing the degree of thermostatic control specified. The Bidder shall provide full wiring diagram of all control circuits giving terminal connection reference.

The control system shall incorporate all necessary safety interlocks for the successful operation of the mechanical plant and system. All of the individual control elements shall be provided by the same manufacturer.

Temperature sensors shall be of the resistance type using nickel based elements and shall be accurate to $\pm$ 1oCover the range of 0 ^{o}C to 30 ^{o}C. The sensor resistance shall be compatible with the measuring bridge of the matching control box.

13.30.15 Electrical Connections

All electrical power control cables and wiring associated with the air conditioning and ventilation systems, including all connections between control panels, valves, thermostats, sensing probes and other like items shall be supplied, installed and connected up as part of this Contract.

The cabling and wiring system shall comply with the requirements of the relevant clauses of this Specification and be either surface or flush installation as appropriate.

Cables and wiring shall comprise either PVCWPVC laid in cleats or trenches, or PVC drawn into galvanised conduits and trunking.

Final connections to electric motors and all other items of plant subject to movement and vibration shall comprise flexible cable in flexible conduit.

13.30.16 Manufacturers

Wherever possible all air conditioning and ventilating plant shall be selected from a single manufacturer's product range and origin. Where this is not possible, because of practical or technical constraints. then the number of different sources of origin shall. be kept to a minimurn. Local service facilities shall be available for the equipment proposed.

The Bidder shall provide, with his submission, illustrated technical literature covering all plant and equipment offered.

13.30.17 Standards

All air conditioning and ventilation equipment shall conform to British Standards, Chartered Institution of Building Services or ASHRAE recommendations or other recognised International Standards with 25% design margin..

13.30.18 Approval

The Bidder shall submit to the Engineer for approval copies of all his calculations forming

the basis for the selection of all air conditioning and ventilating plant, plant selection details and full working drawings. Such approval shall not relieve the Bidder of his contractual responsibilities.

13.30.19 Maintenance

The Bidder shall be responsible for the maintenance of all installations covered by this section of the Specifications for the period stated elsewhere in the Specification.

13.31 EARTHING AND BONDING

All equipment being supplied under this Section shall be effectively bonded to ensure earth continuity throughout the system. Continuity may be provided by means of cable armouring but a separate earth continuity conductor shall be included with all wiring in conduits. No reliance shall be placed on metal to metal joints in conduits for earth continuity. The earth continuity conductors shall as far as possible be in one continuous length to the furthest part of the installation from the controlling switchboard. The earth conductor shall connect all metal cases housing electrical equipment. The branches shall be connected to the main conductor by permanently soldered on mechanically clamped joints.

13.32 TESTING AND COMMISSIONING

The Bidder shall be required to prove that the installed system meets the design requirements and Specification to the satisfaction of the Engineer.

13.33 IP CAMERA SURVEILLANCE SYSTEM

13.33.1 Scope of Work

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the IP camera surveillance system of the complete substation.

13.33.2 Areas to be monitored

In most cases, areas shall be monitored with more than one (1) camera for redundancy. Complete substation including the following areas shall be monitored:

Sl. No.	Installations / areas to be monitored	Camera type
1.	Main gate & other entrances	Bullet & Dome
2.	Complete 360° view of the outermost perimeter of the substation	Bullet
3.	Complete 360° view of AIS & GIS area but focusing on transformers	Bullet
4.	Entrances of office/buildings/other civil instillations	Dome
5.	Indoor stores	Dome
6.	Outdoor stores	Bullet
7.	Indoor type capacitor banks	Dome
8.	Inside of GIS halls, control rooms & sub control rooms	Dome
9.	Equipment rooms for third party vendors (i.e.: Fibre at home, BTCL, UGC, etc.)	Dome
10.	Multi junction roads	Bullet

13.33.3 Basis for Design

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the IP camera surveillance system of the complete substation.

All the cameras shall be viewable (through NVR) to authorized users from outside of the local network using smartphone application. The surveillance live view shall be streamed from the local network via NVR manufacturers secure servers to smartphone app developed by said manufacturer. Having dedicated public IP or port forwarding on routers in the local network shall not be necessary in this regard. Provision shall be kept for viewing cameras (through NVR) centrally from PGCB head office and necessary IP address shall be collected from communication circle office of PGCB.

Cameras shall be mounted using metal shield casing. Surge protective devices shall be installed for protection from direct/indirect lightning, transient over voltage, switching over voltage etc. Ethernet surge protectors shall be installed for rj45 connections from each camera before connecting to access switch. MDB, SDB, racks etc. shall be connected to substation grounding. Ethernet surge arresters shall be grounded via earthing plates of surveillance cabinets. Poles & surveillance cabinets shall be connected to mesh of the substation using earthing rods / cables. The power distribution network of the surveillance system shall not be used for any other purpose other than the surveillance system.

This rj45 connectors or power connectors from cameras at each location shall be housed in a small, easily accessible waterproof box so as to protect the connectors from water splash / rain. Optical fiber cables, ethernet cables, shall be carried through uPVC pipes. Cable wiring, clipping, dressing, earthing & identification shall be done using good quality kits. All equipment (poles, switches, cameras) & connections (rj45, fibers cores / SFP, power cables) shall have proper numbering / marking for easy identification and troubleshooting.

At least Two (2) SFP connections from each access switch shall established, one of them will be connected to main core switch and the other to a backup core switch. For cameras located at the main control building & high gantry structures, at least two (2) runs of CAT6 cables shall be laid for each camera, one (1) of them shall be in use and the other shall be kept as spare with its RJ45 connectors (at both ends) equipped with protective caps. For one or more cameras installed on a pole / structure, at least one (1) CAT6 cable shall be provided which shall be kept as spare with its RJ45 connectors (at both ends) equipped with protective caps.

The equipment in the surveillance network should be EMC compatible and shall work in EHV environment.

13.33.4 Electrical Connections

As appropriate.

13.33.5 Manufacturers

Wherever possible equipment shall be selected from a single Manufacturer's product range and origin. Where this is not possible, because of practical or technical constraints.

then the number of different sources of origin shall. be kept to a minimum. Local service facilities shall be available for the equipment proposed.

13.33.6 Additional information to be included

The contractor shall provide catalogues, brochures with detailed specification for the supplied items.

During execution stage: the contractor shall submit diagram & layout of the surveillance network including fiber, cat6, power cables. Bandwidth calculation at all points on the network shall also be submitted to prove that bottleneck / traffic congestion does not occur at any point. Load calculation of the entire system shall be submitted to prove that UPS capacity is sufficient to provide backup of the full surveillance system for at least 30 minutes. If UPS capacity is not sufficient, higher capacity UPS shall be provided at no additional cost. The contractor shall submit detail detailed diagrams of civil works, poles, camera mountings.

13.33.7 Approval

The Contractor shall submit to the Engineer for approval of the supplied items.

13.33.8 Maintenance

The Contractor shall be responsible for the maintenance of all installations covered by this section of the Specifications for the period stated elsewhere in the bid document.

13.34 Rooftop SPV Power Plant

13.34.1 SCOPE OF WORK

(a) Scope of work covers Design, Supply, Installation, Commissioning and five years comprehensive warranty Maintenance and Operation of SPV Rooftop Plant under Net Metering as per the technical specification given as following.

(b) Wiring up to Distribution Board from the SPV Rooftop system will be in the scope of the Contractor including the cables for every solar power plant installed.

(c) Performance testing of the complete system.

(d) The contractor will collect firm work order from the Client. The technical details of module, PCU, junction boxes, transformer (if required), structure, data collection system, meter, cables, etc. and its test report and Qualifications & Certificates, testing and commissioning report of plant, Net Metering Work Completion & Synchronization reports, installed system photographs, bill of material and As-built drawings has to be submitted to Client.

13.34.2 TECHNICAL SPECIFICATIONS

The proposed projects shall be commissioned as per the technical specifications given below.

The Solar Rooftop Photo Voltaic (SPV) power plant consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPT), Inverter, and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches. PV Array is mounted on a suitable structure. SPV system should be designed with necessary features. Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the IEC or international specifications, wherever such specifications are available and applicable. Solar PV rooftop system shall consist of following major equipment/components. And Contractor shall submit a relative type test certificate (specially capacity test) about (a) & (b) and Factory test certificate about others of (c)~(g) as per IEC or IEEE.

(a) Solar PV modules consisting of required number of Crystalline PV cells.

(b) Grid interactive Power Conditioning Unit with Remote Monitoring System

(c) Mounting structures

(d) SPV P/P monitoring & control system

(e) Junction Boxes.

(f) Earthling and lightening protections.

(g) IR/UV protected PVC Cables, pipes and accessories

13.34.3 SOLAR PHOTOVOLTAIC MODULES:

Solar PV modules should be of the crystalline silicon type. Detailed specifications of the solar PV modules are given below.

Type	**Monocrystalline Silicon**
Minimum rated Power (P_{max})	Not less than 400W per a single PV module at STC (Standard Test Condition)
Efficiency	>= 19%
Warranty	At least 98% of nominal power during first year. Thereafter max 0.54% degradation per year. At least 93% of nominal power upto 10 years and at least 85% of nomina power upto 25 years.

Type	**Monocrystalline Silicon**
Module frame	Non-corrosive and electricaly compatible with the mounting structure material
Termination box	Thermo-plastic, IP 67, UV resistant
Operating Temperature	-40 ~ +85°C
Maximum System Voltage	1,000 V
Maximum Reverse Current	20 A
Mechanical Test Load	5,400 / 2,400 Pa (Push / Pull)
Fire Rating	C / Type 2 (based on ANSI / UL 1703)
Qualifications & Certificates	IEC 61215:2016, IEC 61730:2016
Salt Mist Corrosion Testing	As per IEC 61701:2012
Weight	Not more than 23kg ± 2% (including frame)

The bidder shall carefully design & accommodate requisite numbers of the modules to achieve the rated power in his project proposal submitted to the Client.

The rated output power of any supplied module shall have tolerance of +/- 3%.

The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings.

Each PV module used in solar power project must have a RF identification tag (RFID), which must contain the following information. The RFID can be inside or outside the module laminate, but must be able to withstand harsh environmental conditions.

a. Name of the manufacturer of PV Module

b. Name of the Manufacturer of Solar cells

c. Month and year of the manufacture (separately for solar cells and module)

d. Country of origin (separately for solar cells and module)

e. I-V curve for the module

f. Peak Wattage, Im, Vm and FF for the module

g. Unique Serial No and Model No of the module

h. Date and year of obtaining IEC PV module qualification certificate

i. Name of the test lab issuing IEC certificate

j. Other relevant information on traceability of solar cells and module as per ISO9000 series.

13.34.4 Solar PV Mounting Structure

The PV modules shall be mounted on fixed metallic structures having adequate strength and as per requirement of site to withstand the load of the modules and high wind velocities. The mounting structure steel shall be as per the Chapter 11 (Supporting Structures for Outdoor Equipment) of the Volume 2 of the current Bidding document.

❑ **Detailed specifications for the mounting structure**

Wind velocity withstanding capacity	150 km / hour The designs have been certified by a recognized Lab/Institution/certified engineers in this regard and submit wind loading calculation sheet to users if they desire so. Suitable fastening arrangement such as grouting and calming should be provided to secure the installation against the specific wind speed
Structure material	Pre-galvanized sheet steel with a minimum galvanization thickness of 80 microns and the structural patterns shall be made before galvanizing
Bolts, nuts, panel mounting clamps, fasteners (with spring washers)	Stainless steel SS 304
Mounting arrangement for metal sheet roofs	Mounting directly on the sheet metal, ensuring stability and wind withstanding capacity or penetrating the sheet metal and fixing to the sub-structure, ensuring that the roof remains water proof and ensuring stability and wind withstanding capacity.
Mounting arrangement for elevated structures	The elevated structure has to be securely anchored to the supporting surface. Concrete foundations of appropriate weight and depth for elevated structures mounted directly on the ground; Bolted with anchor bolts of appropriate strength for elevated structures mounted on RCC surfaces.

Mounting arrangement for ground installations	With removable concrete ballast made of pre-fabricated PCC (1:2:4), M15; assuring enough ground clearance to prevent damage of the module through water, animals and other environmental factors.
Mounting arrangement for RCC-flat roofs	With removable concrete ballast made of pre-fabricated PCC (1:2:4), M15. The structures shall be designed for simple
Installation	mechanical on-site installation. There shall be no requirement of welding or complex machinery at the installation site.
Minimum distance	Between foundation and module: 0.5m Between roof edge and mounting structure: 0.5m
Access for panel cleaning and maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the module- junction box.
Panel tilt angle	North – south orientation with a fixed tilt angle of 20-30 degrees (depending on location), south facing. However to accommodate more capacity the angle inclination may be reduced until the plant meets the specified performance ratio requirements.

Regarding civil structures the Contractor need to take care of the load bearing capacity of the roof and need arrange suitable structures based on the quality of roof.

13.34.5 Solar Array Fuse

The cables from the array strings to the solar grid inverters shall be provided with DC fuse protection. Fuses shall have a voltage rating and current rating as required. The fuse shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP 65 enclosures with transparent covers.

13.34.6 Solar Grid Inverter

As SPV array produce direct current electricity, it is necessary to convert this direct current into alternating current and adjust the voltage levels to match the grid voltage. Conversion shall be achieved using an electronic Inverter and the associated control and protection devices. All these components of the system are termed the “Power Conditioning Unit (PCU)”. In addition, the PCU shall also house MPPT (Maximum Power Point Tracker). Inverter output should be compatible with the grid frequency. Typical

technical features of the inverter shall be as follows:

1	Total output power (AC)	To match solar PV plant capacity while achieving optimum system efficiency
2	Input DC voltage range	As required for the solar grid inverter DC input
3	Maximum power point (MPPT)	Shall be incorporated
4	Switching devices	IGBT/MOSFET
5	Control	Microprocessor /DSP

6	Nominal AC output voltage and frequency	415V, 3P4W Phase, 50Hz
7	Output frequency	50 Hz (Operating range: 47.5 – 52.5 Hz)
8	Grid Frequency Synchronization range	+ 3 Hz or more
9	Power factor of the inverter	> Built-in Protection 0.98 at nominal power
10	Total harmonic distortion	Less than 3%
11	Built-in Protection	AC high / low voltage; AC high /low frequency
12	Anti-islanding protection	As per VDE 0126-1-1 / IEC 60255.5/ IEC 60255.27 / IEC 62116
13	Operating ambient temperature range	+4 ^{o}C to +45 ^{o}C
14	Humidity	0 ~ 95% Rh
15	Inverter efficiency	>=95%
16	Inverter weighted efficiency	>=94%
17	Protection degree	IP 65 for outdoor mounting, IP 54 for indoor mounting
18	Communication interface	RS 485 / RS 232 / RJ45
19	Safety compliance	IEC 62109-1, IEC 62109-2
20	Environmental Testing	IEC 60068-2 (1, 2, 14, 30)
21	Efficiency Measurement Procedure	IEC 61683
22	Cooling	Convection

23	PCU house installed on the Roof	Requirement of the PCU house 1. Foundation : Reinforced concrete 2. External wall & roof : Sandwich panel 3. Post : Miscellaneous steel 4. Others : Four side walls shall be equipped with an adjustable louver to cool the heat generated by the inverter
24	Display type	LCD for data display. LCD /LED for status display
25	Display parameters to include	Output power (W), cumulative energy (Wh), DC voltage (V), DC current (A), AC voltage (V), AC frequency (Hz), AC current (A), cumulative hours of operation (h).

The combined wattage of al inverters should not be less than rated capacity of power plant under STC.

PCU/inverter shall be capable of complete automatic operation including wake-up, synchronization & shutdown. The output of power factor of PCU inverter is suitable for all voltage ranges or sink of reactive power, inverter should have internal protection arrangement against any sustainable fault in feeder line and against the lightning on feeder. Built-in meter and data logger to monitor plant performance shall be provided.

The PCU/ inverters should be tested from the approved test centres of IEC accredited testing- calibration laboratories.

13.34.7 GRID ISLANDING

In the event of a power failure on the electric grid, it is required that any independent power- producing inverters attached to the grid turn off in a short period of time. This prevents the DC-to-AC inverters from continuing to feed power into small sections of the grid, known as “islands.” Powered islands present a risk to workers who may expect the area to be unpowered, and they may also damage grid-tied equipment. The Rooftop PV system shall be equipped with islanding protection. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided.

A manual disconnect 4pole isolation switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personnel to carry out any maintenance. This switch shall be locked by the utility personnel

The AC output of the solar grid inverter shall be connected to the building’s electrical system after the Net meter and main switch on the load side. The solar grid inverter output shall be connected to a dedicated module in the Main Distribution Board (MDB) of the building. It shall not be connected to a nearby load.

13.34.8 DATA ACQUISITION SYSTEM / PLANT MONITORING

Data Logging Provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable PC, Metering and Instrumentation for display of systems parameters and status indication to be provided. Solar Irradiance: An integrating Pyranometer / Solar cell based irradiation sensor (along with calibration certificate) provided, with the sensor mounted in the plane of the array. Readout integrated with data logging system. Temperature: Temperature probes for recording the Solar panel temperature and/or ambient temperature to be provided complete with readouts integrated with the data logging system. The following parameters are accessible via the operating interface display in real time separately for solar power plant:

a. AC Voltage.
b. AC Output current.
c. Output PowerPower factor.

d. DC Input Voltage.

e. DC Input Current.

f. Time Active.

g. Time disabled.

h. Time Idle.

i. Power produced

Protective function limits (Viz-AC Over voltage, AC Under voltage, over frequency, Under frequency ground fault, PV starting voltage, PV stopping voltage.

All major parameters available on the digital bus and logging facility for energy auditing through the internal microprocessor and read on the digital front panel at any time) and logging facility (the current values, previous values for up to a month and the average values) should be made available for energy auditing through the internal microprocessor and should be read on the digital front panel. PV array energy production: Digital Energy Meters to log the actual value of AC/ DC voltage, Current & Energy generated by the PV system provided. Energy meter along with CT/PT should be of 0.5 accuracy class. Computerized DC String/Array monitoring and AC output monitoring shall be provided as part of the inverter and/or string/array combiner box or separately. String and array DC Voltage, Current and Power, Inverter AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency shall be monitored. Computerized AC energy monitoring shall be in addition to the digital AC energy meter. The data shall be recorded in a common work sheet chronologically date wise. The data file shall be MS Excel compatible. The data shall be represented in both tabular and graphical form. All instantaneous data shall be shown on the computer screen. Software shall be provided for USB download and analysis of DC and AC parametric data for individual plant. Provision for Internet monitoring and download of data shall be also incorporated.

Remote Server and Software for centralized Internet monitoring system shall be also provided for download and analysis of cumulative data of all the plants and the data of the solar radiation and temperature monitoring system. Ambient and Solar PV module back surface temperature shall be also monitored on continuous basis. Simultaneous monitoring of DC and AC electrical voltage, current, power, energy and other data of the plant for correlation with solar and environment data shall be provided. Remote Monitoring and data acquisition through Remote Monitoring System software at the owner with latest software & hardware configuration and service connectivity for online, real time data monitoring & control complete to be supplied and operation & maintenance control to be ensured by the supplier.

13.34.9 POWER CONSUMPTION:

Regarding the generated power consumption, priority need to give for internal consumption.

13.34.10 PROTECTIONS

The system should be provided with all necessary protections like earthing, Lightning, and grid islanding as follows:

13.34.11 LIGHTNING PROTECTION

The SPV power plants shall be provided with lightning & overvoltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. The entire space occupying the SPV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors. Lightning protection should be provided as per IEC 62305 /IS 2309 standard. The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOVs) and suitable earthing such that induced transients find an alternate route to earth.

13.34.12 SURGE PROTECTION

Surge protection shall be provided on both the DC and the AC side of the solar system. The DC surge protection devices (SPDs) shall be installed in the DC distribution box adjacent to the solar grid inverter.

The AC SPDs shall be installed in the AC distribution box adjacent to the solar grid inverter. The SPDs earthing terminal shall be connected to earth through the above mentioned dedicated earthing system. The SPDs shall be of type 2 as per IEC 60364-5-53.

13.34.13 EARTHING PROTECTION

(a) Each array structure of the PV yard should be grounded/ earthed properly as per Chapter 7 (Earthing system and lightning protection) of the Volume 2 of the current Bidding document. In addition, the lighting arrester/masts should also be earthed inside the array

field. Earth Resistance shall be tested in presence of the Client and Consultant. PCU, ACDB and DCDB should also be earthed properly.

(b) Earth resistance shall not be more than 5 ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

13.34.14 CABLES

Cables of appropriate size to be used in the system shall have the following characteristics:

a. Shall meet IEC 60227/IS 694, IEC 60502/IS1554 standards Temp. Range: – 10oC to +80oC. Voltage rating 600/1000V

b. For the DC cabling, Solar cables with multi stranded copper conductors XLPE or XLPO insulated and sheathed with the voltage rating of 1000 V DC or higher UV stabilised single core flexible copper cables shall be used. Multi-core cables shall not be used.

c. For the AC cabling, PVC or XLPE insulated and PVC sheathed single or multi-core flexible copper cables shall be used. Outdoor AC cables shall have a UV-stabilised outer sheath

d. The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 1.0%.

The total voltage drop on the cable segments from the solar grid inverter to the building distribution board shall not exceed 2.0%

e. The DC cables from the SPV module array shall run through a UV-stabilised PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm or through a High Density Poly Ethylene (HDPE) conduit. The conduits shall not run across the path way of the terrace. Flexible corrugated PVC conduits shall not be used.

f. Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers.

g. All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm. The minimum DC cable size shall be 4.0 mm2 copper. The minimum AC cable size shall be 4.0 mm2 copper for up to 10kWp and 16.0mm2 for above 10kWp / required standard size. In three phase systems, the size of the neutral wire shall be equal to the size of the phase wires. The following colour coding shall be used for cable wires:

13.34.15 TOOLS & TACKLES AND SPARES

After completion of installation & commissioning of the power plant, necessary tools &

tackles are to be provided free of cost by the bidder for maintenance purpose.

13.34.16 DANGER BOARDS AND SIGNAGES

Danger boards should be provided as and where necessary as per related Act and rules as amended up to date. Three signage shall be provided one each at control room, solar array area and main entry from administrative block. Text of the signage may be finalized in consultation with Client.

13.34.17 FIRE EXTINGUISHERS

The firefighting system for the proposed power plant for fire protection shall be consisting of: Portable fire extinguishers in the control room for fire caused by electrical short circuits Sand buckets in the control room. The installation of Fire Extinguishers should confirm to the regulations and standards of Bangladesh. The fire extinguishers shall be provided in the control room housing PCUs as well as on the Roof or site where the PV arrays have been installed.

13.34.18 DRAWINGS & MANUALS

Two sets of Engineering, electrical drawings and Installation and O&M manuals are to be supplied.

13.34.19 PLANNING AND DESIGNING

The bidder should carry out Shadow Analysis at the site and accordingly design strings & arrays layout considering optimal usage of space, material and labor.

13.34.20 SAFETY MEASURES

The bidder shall take entire responsibility for electrical safety of the installation(s) including connectivity with the grid and follow all the safety rules & regulations applicable as per related Act and Rules.

13.34.21 DC COMBINER BOX

A DC Combiner Box shall be used to combine the DC cables of the solar module arrays with DC fuse protection for the outgoing DC cable(s) to the DC Distribution Box.

13.34.22 DC DISTRIBUTION BOX

A DC distribution box shall be mounted close to the solar grid inverter. The DC distribution box shall be of the thermo-plastic IP65 DIN-rail mounting type and shall comprise the following components and cable terminations:

i. Incoming positive and negative DC cables from the DC Combiner Box;

ii. DC circuit breaker, 2 pole (the cables from the DC Combiner Box will be connected to this circuit breaker on the incoming side);

iii. DC surge protection device (SPD), class 2 as per IEC 60364-5-53;

iv. Outgoing positive and negative DC cables to the solar grid inverter.

As an alternative to the DC circuit breaker a DC isolator may be used inside the DC Distribution Box or in a separate external thermoplastic IP 65 enclosure adjacent to the DC Distribution Box. If a DC isolator is used instead of a DC circuit breaker, a DC fuse shall be installed inside the DC Distribution Box to protect the DC cable that runs from the DC Distribution Box to the Solar Grid Inverter.

13.34.23 AC DISTRIBUTION BOX

An AC distribution box shall be mounted close to the solar grid inverter. The AC distribution box shall be of the thermo plastic IP65 DIN rail mounting type and shall comprise the

following components and cable terminations:

a. Incoming 3-core / 5-core (single-phase/three-phase) cable from the solar grid inverter

b. AC circuit breaker, 2-pole / 4-pole AC surge protection device (SPD), class 2 as per IEC 60364-5-53

13.34.24 METERING

The existing service connection meter needs to be replaced with a bidirectional (import kWh and export kWh) service connection meter for the purpose of net-metering for eligible categories. Installation of the net meter will be carried out by the authorized body.

13.34.25 DOCUMENTATION

The Installer shall supply the following documentation:

a. System description with working principles.

b. System design document including drawings.

c. All the test and commissioning, performance test result etc.

d. Warranty of Qualifications and Certificates

e. Solar PV array lay-out.

f. Routing diagram of cables and wires.

g. Data sheets, drawings and user manuals of the all equipment and system.

h. A system operation and maintenance manual including As-built drawings.

i. Name, address, mobile number and email address of the service centre to be contacted in case of failure or complaint.

j. Warranty cards.

k. Maintenance registers.

13.34.26 TEST CERTIFICATES AND REPORTS TO BE FURNISHED

Test Certificates / Reports from the accredited laboratory for relevant IEC standard for quoted components shall be furnished. Type Test Certificates / reports shall be provided for the solar modules and solar grid inverters. (self-certification by the manufacturer of the said inverter is acceptable.)

13.34.27 GENERAL INSTRUCTIONS

(a) Water and power supply for the construction shall be the responsibility of the Contractor/Bidder

(b) Security, safety, watch, and ward of al materials at sites shall be the responsibility of the Contractor/Bidder

(c) Expenses for any other works, supply of material, and providing services required for the successful commissioning and operation of the plant, but not specifically mentioned in this document.

(d) Safety management to be strictly complied with by the Contractor/Bidder throughout implementation activity.

(e) First-aid medical facilities at the Site during construction to be provided by the Contractor/ Bidder(s)

(f) All local labor, employment, and other issues shall be handled independently by the Contractor/ Bidder(s)

(g) The entire responsibility and risk relating towards the workforce working at the Site, and compliance of different statutory regulations like Workman Compensation Act, Employees' State Insurance Corporation (ESIC), Factory Act, Contract Labour Regulation, and Abolition Act, Shop and Establishment Act, and other Statutory regulatory bodies shall solely lie with the Contractor/ Bidder(s).

(h) The Contractor/ Bidder(s) shall also be solely responsible for payment of wages, provident fund, bonus, retrenchment compensation leave, etc. applicable as per various statutory regulations to their entire workforce,

(i) Location and area for inverter and another interconnection equipment should be located in suitable and secure place and this should be approved by the Client.

(j) Installation diagram and wiring from array to proposed location of inverter and interconnection should be clearly presented by the Contractor before work starts on the site.

(k) Any installations on the roof should be planned and executed in such a way that water proofing will not be disturbed and harmed. In case any area water proofing is affected it will be the Contractor's responsibility to correct it and put it right.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 14

FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND PROTECTION

SECTION 14

FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND PROTECTION

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SECTION 14

FIBRE OPTIC MULTIPLEXER AND POWER LINE CARRIER EQUIPMENT FOR COMMUNICATION AND PROTECTION

This specification describes the communication requirements for the transport of voice, data and protection signals between the new substations existing substations and the National Load Dispatching Centre (NLDC & BNLDC) in Rampura and Siddirganj, including engineering, configuration, testing, installation, commissioning and training.

The scope of work is to connect the Substation Automation System to the existing communication system to be installed under this contract for securing the transport of voice, data and protection signals, complete system for new substations and extension and integration into the existing system for existing substations.

The scope of work is to connect REMOTE END substations, too. All necessary equipment, material and services shall be included in the contract price.

OPGW with 48 cores of optical fibre in 400kV, 230kV & 132kV Overhead Line will be installed by the transmission Line Contractor, but this optical fibre will be used for optical connection for Fiber Optic Multiplexer Equipment and Line/Current Differential Protection of the 400 kV, 230 kV & 132 kV line.

All materials and equipment offered shall be brand new, from the Manufacturer's normal and standard construction, designed and manufactured according the latest technological methods.

For the purpose of standardisation of operating performance and facilities offered equipment shall be compatible with the existing ones.

For standardization of operation performance, facilities and spare requirements, the fibre optic multiplexer equipment for communication and protection to be supplied under this project shall consist of equipment which can totally be integrated into the existing telecommunication system in PGCB's network, including the telecommunication network management system. The fibre optic multiplexers presently used in PGCB’s network are:

- Hitachi FOX 515/615, and

- GE MSE 5001, MSE 5010
- Huawei OSN 1800V, E6616

The Manufacturer of Telecommunication system – Fibre optic multiplexer equipment for communication and protection shall be: Hitachi Energy (Switzerland)(Former ABB), , GE (Former Alstom/Areva), HUAWEI (China).

Any other Manufacturer of Telecommunication system shall have to fulfil the Qualification Criteria required in sub-clause 2.6. of Section 3 of Volume 1 of Tender documents

14.1 Summary of Standards

The Equipment shall comply with the latest ITU-T recommendations for the Plesiochronuous, synchronous hierarchies & multiprotocol label switching-transport -profile.

The equipment shall be KEMA type tested.

14.1.1 PDH Interfaces

The PDH interfaces shall conform to the following recommendations:

ITU

ITU-T G.702	General aspects of digital transmission systems - Terminal equipment Digital hierarchy bit rates
ITU-T G.703	Digital transmission systems - Terminal equipment - General Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.704	Digital transmission systems - Terminal equipment - General Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels
ITU-T G.706	General aspects of digital transmission systems - Terminal equipment- Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in recommendation G.704
ITU-T G.71 1	Pulse code modulation (PCM) of voice frequencies
ITU-T G.712	Transmission performance characteristics of pulse code modulation channels
ITU-T G.732	General aspects of digital transmission systems - Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s

ITU-T G.735	Characteristics of primary multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
ITU-T G.736	General aspects of digital transmission - Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s
ITU-T G.737	Characteristics of external access equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
ITU-T G-823	The control of jitter and wander within digital networks, which are based on the 2048 kbit/s hierarchy
ITU-T G.826	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

14.1.2 Architecture of Optical SDH Interfaces

The architecture of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 147:	Synchronous digital hierarchy multiplexing structure
ETS 300 417:	Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment
ETS 300 417-1-1 / EN 300 417-1-1 V 1. 1.2:	Generic Processes and Performance
ETS 300 417-2-1 / EN 300 417-2-1 VI.1.2:	SDH and PDH Physical Section Layer Functions
ETS 300 417-3-1 / EN 300 417-3-1 V 1. 1.2:	STM-N Regenerator & Multiplex Section Layer Functions
ETS 300 417-4-1 / EN 300 417-4-1 V 1. 1.2:	SDH Path Layer Functions

ITU

ITU-T G.707	Network node interface for the synchronous digital hierarchy
ITU-T G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T G.803	Architecture of transport networks based on the synchronous digital hierarchy (SDH)
ITU-T G.805	Generic functional architecture of transport networks
ITU-T G.826	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate
ITU-T G.841	Types and characteristics of synchronous digital hierarchy (SDH) network protection architectures
ITU-T G.957	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
ITU-T G.958	Digital line systems based on the synchronous digital hierarchy for use on optical fibre cables
ITU-T M.2101.1	Performance limits for bringing into service and maintenance of international SDH paths and multiplex section
ITU-T T.50	International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange

14.1.3 Synchronisation and Timing of Optical SDH Interfaces

The synchronisation and timing of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 417-6-1 / EN 300 417-6-1 V 1. 1.2	Synchronisation Layer Functions
ETS 300 462-1 / EN 300 462-1-1 V 1. 1. 1	Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 1: Definitions and terminology for synchronisation networks.

EN 300 462-4-1 V1.1.1	Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 4-1: Timing characteristics of slave clocks suitable for synchronisation supply to Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH) equipment
ETS 300 462-5 / EN 300 462-5-1 V1.1.2	Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 5: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment

ITU

ITU-T G.813:	Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC)

14.1.4 Architecture of MPLS-TP Interfaces

The architecture of MPLS-TP interfaces shall conform to the following recommendations

ITU

ITU-T G.8112/Y.1371 MPLS-TP Interface

ITU-T G.8113: Operations, administration and maintenance mechanisms for MPLS-TP in packet transport networks.

14.2 Abbreviations

ADM	Add-drop multiplexed
ALS	Automatic Laser Shutdown
BIP	Bit Interleaved Parity
CAP	Carrier-less Amplitude and Phase
CAS	Channel Associated Signalling
CRC	Cyclic Redundancy Check
DTMF	Dual Tone Multi-Frequency
EN	European Norm
EOW	Engineering Order Wire
ETS	European Telecommunications Standards
GPS	Global Positioning System
HDSL	High Density Subscriber Line

IEC	International Electrical Commission
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
LAN	Local Area Network
MCMI	Multi Coded Mark Inversion
MS	Multiplex Section
NE	Network Element
NMS	Network Management System
OS	Optical Section
OSPF	Open Shortest Path First
PDH	Plesiochronous Digital Hierarchy
PPP	Point-to-Point Protocol
RS	Regenerator Section
SDH	Synchronous Digital Hierarchy
SNMP	Simple Network Management Protocol
SOH	Section Overhead
STM	Synchronous Transport Module
TCP	Transmission Control Protocol
TTI	Trail Trace Identifier
VC	Virtual Container
MPLS-TP	Multiprotocol Label Switching- Transport Profile
VF	Voice Frequency

14.3 General Requirements

The digital multiplex equipment shall be universal, software-controlled, and provide various interface cards to connect tributary interfaces signals such as voice, teleprotection and data to aggregate interfaces. On aggregate level 2Mbit/s and 8Mbit/s electrical interfaces complying with ITU-T recommendations G.703 / G.704, G.8112/Y.1371 shall be available. In addition, optical STM-1/STM-4/STM-16 and/or Ethernet 1GE/10GE aggregate interfaces shall be available. All modules shall form an integrated part of a shelf.

The multiplexer shall provide means to drop and insert individual 64 kbit/s signals and allocate them to determined time slots in the 2Mbit/s streams. Path protection on 64 kbit/s and 2Mbit/s shall be supported.

It shall be suitable for operation in substation with harsh environment with high electromagnetic interference, be highly reliable and provide secure communication for real time signals such as voice, SCADA, teleprotection and status/control signals.

The equipment offered shall already be working successfully in telecommunication networks operated by power utilities. It shall comply to the latest ITU-T standards and be able to be interconnected with telecommunication equipment.

Any equipment in the network shall be manageable from a control centre and there shall be means to supervise external/existing equipment as well.

As a minimum modules for the following user signals shall be available as plug-in units for the digital multiplexer:

- Analogue subscriber interface: subscriber and exchange side
- G.703, 64kbit/s data Interface
- Alarm collection interface
- Teleprotection command interface
- Binary signal (status and control) interface
- 2Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704.

Additionally, the equipment shall provide the following aggregate interfaces:

- STM-4 (622 Mbit/s) optical 1+1 interface for medium and long distances, with automatic laser shut down.
- STM-1 (155 Mbit/s) / STM-4 (622 Mbit/s) optical add-drop interface for medium and long distances, with automatic laser shut down
- 2 Mbit/s electrical interface

The equipment may provide 1GE/10 GE Ethernet interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

14.4 General Conditions

The same equipment shall be used as a terminal, for through connections (transit, repeater) and as add-drop multiplexer (ADM) with integrated optical line modules.

- First order multiplexing (2048 Kbit/s), second order multiplexing (8448 Kbit/s/s) and STM-1/STM-4 or STM-16 & 1Gbps/10 Gbps multiplexer shall be integrated.

Conference for voice channels and point-multipoint function for data signals shall be possible.

The equipment shall be of fully modular design, based on a single cubicle.

14.4.1 Channel Capacity: Digital Cross Connection

The equipment shall be equipped with a redundant cross connection function with decentralised cross connection functions on each board.

The cross connect capacity shall be minimum 40x 2Mbit/s, or 200x 64kbit/s non-blocking.

14.4.2 Redundant Centralised Functions

The equipment shall be equipped with redundant circuits for all centralised functions.

14.4.3 Power Supply

The multiplex equipment shall operate at 48VDC +/- 15%. Redundant power-supply shall be supported.

14.4.4 ITU Compliance

The Equipment shall comply to the latest ITU-T recommendations for the plesiochronuous, synchronous hierarchies & multiprotocol label switching-transport - profile such as:

G.702-704, G.706, G.711-714, G.732, G.735-737, G.742, G.826, G.823, G.8112/Y.1371, Q-552

14.4.5 Electromagnetic Compatibility and Safety Regulations

The equipment shall comply with the EN50022, EN50082, IEC 801-2, IEC 801-6 and shall be conformant with CE.

14.4.6 Ambient Conditions

Storage and transport: -40... +70˚C; 98% (no condensation)

Operation: -5... +45˚C, humidity of max. 95% (no condensation)

14.4.7 Mechanical Construction

The equipment shall be of robust design. All tributary and aggregate units shall be integrated in the same shelf.

All connectors shall be accessible from the front.

14.4.8 Network Management System

The equipment shall be software programmable, by both a local craft terminal - preferably notebook and a centralised Network Management System (NMS).

Traffic through the multiplexer shall under no circumstances depend on Network Management System; i.e. the multiplexer has to operate without being connected to any management system.

The Network Management System shall be used to supervise & configure the tele-protection, PDH/SDH/MPLS-TP equipment.

14.4.9 1+1 Path Protection

The equipment shall protect communication channels. The protection shall be end to end from one interface (telephone or data) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm.

The switching shall be done within the multiplexer without using the network management system.

14.4.10 1+1 Section Protection

The equipment shall provide multiplexing section protection. It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed.

The switching shall be done within the multiplexer without using the Network Management System.

14.4.11 Network Topology

It shall be possible to build point to point, linear, ring, T, and meshed networks.

14.4.12 Synchronisation

The equipment shall be synchronisable with an external centralised clock, with connected 2.048 Mbit/s signals and/ or with internal oscillator. The synchronisation shall be configurable and it shall be possible to distribute the synchronisation to other equipment as well.

The system shall have means to switch to select the synchronisation source as well as means to prevent the system from switching synchronisation loops. The equipment shall be capable select the synchronisation source by means of the SSM (Synchronisation Status Messaging) feature according to ITU-T G.704 or priority based.

14.4.13 Alarms

Each module shall supervise its functions and shall have an alarm-indication LED on its front. All alarms shall be collected by the NMS.

Each node shall be capable to collect up to 50 external alarms.

14.4.14 Test Loops

The equipment shall provide means to loop signals on 64kBit/s level as well as on 2Mbit/s level. It shall indicate an alarm if a loop is activated. It shall have the possibility to determine the time after which an activated loop is switched back.

14.4.15 Maintenance Facilities

Every Network Element shall have a built-in Signal Generator and Analyser to analyse communication paths. It must be possible to cross connect the Generator and Analyser to transmission channels and terminate the signal in other Network Elements. The configuration must be possible locally with the craft access terminal and remotely with the NMS or the craft access terminal.

It must be possible to loop-back signals locally and remotely using the craft access terminal or the NMS.

14.5 Requirements for Transport Level

14.5.1 SDH Aggregate Units

The interface shall be designed for use on single mode fibre at 1310nm and 1550nm

The following main functions shall be supported:

- Termination of the OS-, RS-, MS- and VC-4 layer
- Extraction and insertion of the SOH communications information through connections of VC-12 and VC-3

The following maintenance functions shall be supported:

- Status indications
- Loops
- Restart after ALS
- TTI monitoring
- BIP Error Insertion

The following SDH interfaces shall be available:

- STM-1/4 for 132kV & lower voltage level
- STM-4/16 for 230kV voltage level
- STM-16 for 400kV voltage level
- The number of optical port shall be as per field requirement

This interface shall provide Multiplex Section Protection (MSP): 1+1 Section Protection

- 2Mbit/s & 64kbit/s electrical interface
- The number of port shall be as per field requirement

14.5.2 MPLS-TP Aggregate Units

The interface shall be designed for use on single mode fibre at 1310nm and 1550nm

The following main functions may be also supported:

- MPLS forwarding
- Pseudo-wire (PWE3)
- Bi-directional LSPs
- Static Provisioning

The following maintenance functions shall be supported:

- Continuity Check (CC)
- Connectivity Verification (CV)
- Loopback (LB)
- Remote Defect Indication (RDI)
- Loss Management (LM)
- Delay Measurement (DM)

The following MPLS-TP interfaces shall be available:

- 1/10 Gbps
- The number of optical ports shall be as per field requirement

14.6 Tributary Units

14.6.1 Analogue Subscriber Interface

An interface with at least 10 subscribers as well as high-density analogue subscriber card with 60 subscribers shall be available. The ringing generator shall be integrated in the subscriber module interface. The ringer frequency shall be adjustable for 20Hz, 25Hz, and 50Hz.

The following main functions shall are supported:

Downstream signalling:

- Ringing
- Metering
- Polarity reversal
- Reduced battery
- No battery

Upstream signalling:

- On/off-hook
- Pulse and DTMF dialling
- Flash impulse
- Earth key

General:

- Constant current line feeding
- Line test
- Permanent line checks
- CLIP (On-hook VF transmission)
- Metering after on-hook

14.6.2 Exchange Interface

This interface shall provide 12 interfaces to connect remotely connected analogue subscribers to an exchange. It shall provide the following functions:

- pulse dialling
- tone dialling (DTMF)
- earth key function
- metering function(12 kHz or 16 kHz)

- flash impulse
- polarity reversal
- indication of busy lines

The following parameters shall be configurable by software:

- input voice level -5 to +4 dBr
- output voice level -7.5 to -1 dBr
- metering pulse enable/disable
- signalling bit definition
- loop back of voice to the telephone

14.6.3 64 kbit/s Co-directional Interface

This interface shall comply with the ITU-T G.703 part 1.2.1 for co-directional data transfer. A module shall have at least 8 interfaces.

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.6.4 Ethernet Interface

There shall be a 10BaseT interface available with Router Bridge and FRAD Function available. The following specification shall be covered:

Ethernet connection: 10baseT

LAN protocols: IP, IPX

Routing protocols: static IP route, OSPF2 V2

WAN protocols: PPP, Frame Relay (including RFC 1490)

The interface shall be manageable locally, remotely, with the management system of the platform. The LAN interface shall support linear-, ring- and star-configurations. The WAN side shall support link capacities n*64kBit/s and 2Mbit/s.

14.6.5 Alarm Interface

This interface shall provide means to collect various alarms, which will be displayed, on the network management system. It shall be used to manage non-PDH equipment with the PDH network management system.

It shall have at least 24 binary inputs and at least 4 outputs, which can be switched by the network management system.

It shall be possible to connect an input to an output so that if an alarm occurs, the output contact will be switched.

It shall be possible to label an alarm. The label-text shall be read from the interface module so that it can be indicated on the network management system as well as on the local craft terminal.

14.6.6 Teleprotection Interface

The protection of the overhead lines shall be arranged as detailed in Section 5. Teleprotection equipment shall be provided for permissive tripping and direct tripping on the lines.The permissive tripping signals are required to operate circuit breaker trip relays in conjunction with the distance protection and directional earth fault relays.The direct tripping signals are required to operate remote circuit breaker tripping relays.

Technical Requirements

This interface shall provide means to transmit four bi-directional command channels. The signals shall be adjustable from 24 to 250VDC by means of software.

All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

Security, dependability and transmission speed shall be selectable and programmable.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The interface shall support T-nodes.

The teleprotection interface shall provide an integrated non-volatile event-recorder which shall be synchronisable either internally or by GPS or a command counter which counts trip commands.

The teleprotection interface shall provide means for signal delay measurement.

1+1 protection must be available; the switching shall be done within less than 10ms. The interface shall do automatic loop test every 60s.

Under no circumstances shall the interface cause trip-commands in case of power supply failure or when put in or out of service.

It shall be possible to synchronise all teleprotection interfaces with one GPS in one station. The GPS time shall be distributed over the teleprotection channel.

An 8-bit command addressing shall be used to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.

14.6.7 Optical Protection Relays Interface

This interface shall have an optical port to connect protection relays for teleprotection to the multiplexer. It shall operate on 1300nm use MCMI line coding and be suitable for teleprotection relays. Optical Interface of Fiber Optic Multiplexer must comply with IEEE C37.94 protocol for differential protection.

14.6.8 Binary Contact Interface

- This interface shall provide means to transmit binary signals.
- The inputs and outputs shall be isolated.
- The inputs shall be suitable for 24VDC to 60VDC.
- Outputs shall be solid state relays.
- The interface shall provide a 24VDC short circuit proofed auxiliary power supply.
- It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.
- The teleprotection interface shall provide an integrated event recorder, which shall be synchronisable either internally or by GPS.

14.6.9 2Mbit/s G.703 / G.704 Interface

- This interface shall comply with the ITU-T G.703 and G.704 recommendations.
- The interface module shall have at least four interfaces to be activated individually. It shall be possible to have 128 interface modules a multiplexer.
- In order to connect different equipment, the interfaces shall be available with the impedance of 120 ohms and 75 ohms.
- The interface shall support CRC-4 multi-frame according to ITU-T G.704 (enabled and disabled by software).
- The CAS signalling according to ITU-T G.704 table 9 shall be activated optionally.
- The interface shall be able to extract the 2.048 MHz clock, which can be used to synchronise the multiplex equipment.
- The interface module shall support 2Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals.

14.7 Telephone System

An IP phone facility shall be provided at each new substation. The IP phone shall be incorporated by IP connection from upstream substation through IP network in the operational telephone system which is controlled from the existing call manager at NLDC Dhaka. At least three IP telephone sets proper to above mentioned administrative telephone system shall be provided at each new substation.

New substations will become remote subscribers in the administrative telephone system.Facility for minimum 10 x 2W remote subscribers shall be provided and installed at the substation and the remote subscribers shall be connect with the nearest existing exchange of the existing telephone network.

Necessary cards required at the nearest exchange and its associated multiplexer shall be included in the contract price. At least three telephone sets proper to the above mentioned administrative telephone system shall be provide at each new substation

The trunk numbering plan shall be compatible with the present scheme in service in Bangladesh.

The telephone signalling (dialling) system shall be compatible with the present system.

An alarm system shall be provided to indicate traffic failure including blown fuses, loss of power supply, etc. In addition, contacts shall be provided to facilitate extension of the alarms to the telecontrol equipment.

14.8 Communications DC Power Supply Equipment

14.8.1 General

14.8.1.1 Basis of Design

The equipment shall comply with IEC 60146 and 60478.

The charger shall be of either the Thyristor-controlled type or of the SMPS type. The battery shall be nickel cadmium type - as detailed in a separate section of this Specification.

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years, when operating under the specified service conditions.

14.8.1.2 Operating Principle

The output of the charger shall, during normal operation, continuously supply the power requirements of the load whilst simultaneously maintaining the battery charge in the float charge mode. In the event of an interruption in the a.c. mains supply to the charger, the battery shall supply the load requirements for not less than the specified standby time - whilst maintaining the output voltage within permissible limits.

Upon restoration of the a.c. mains supply, the rectifier shall automatically resume supply of the load requirements whilst simultaneously recharging the battery at the float voltage.

14.8.2 Configuration

The power supply installation shall comprise two batteries and two charging sources. each charger shall be able to float charge both batteries as well as supplying the total load.

The total battery capacity shall be able to supply the total load (comprising the delivered load together with 25%. spare for future use) for at least 5 hours in the event of failure of the a.c. mains supply.

The d.c. power supply equipment is required to limit the output voltage to the load within plus 15% and minus 15% of the nominal value, provided these values do not exceed the voltage guarantee of the load equipment. The power supply output positive shall be earthed.

14.8.3 Charger

14.8.3.1 General

The charger shall operate according to the constant voltage current limiting principle and shall incorporate a soft start feature to gradually accept load on initial energising.

The charger shall restart automatically upon restoration of the a.c. mains supply following a mains supply interruption, and recharge the battery at the float voltage.

Internal cooling shall be by natural ventilation. Forced cooling is not acceptable.

The charger shall be suitable for operation in parallel with one or more chargers, and shall include a current sharing facility.

The charger shall be of sufficient output capacity for the application, parallel operation of chargers (where required) is for the purpose of redundancy and not to satisfy the output current requirements.

14.8.3.2 Charger Output

The output characteristic shall provide an output voltage regulation of ±1%, over the specified a.c. mains voltage and frequency range and for load changes 0-100%. The output voltage regulator shall be adjustable within limits approved by the Engineer and shall be so designed that special tools are not required for such adjustment. Compensation for battery temperature shall be provided.

The charger shall have protection against overloads or short circuits and shall limit the output current.

Recovery to a constant voltage characteristic shall occur automatically at the end of the overcurrent/short circuit.

14.8.3.3 Boost Charging

Both Auto &Manual boost charging shall be provided. A boost timer shall be included to prevent overcharging.

Operation of boost charging shall not disconnect the charger and battery from the load. The load shall be connected to DC charger during boost charging. However, provision may be applied so that, it shall not be possible for both chargers to be selected to boost charging at the same time, or for the load to become disconnected from both batteries and chargers simultaneously.

If the a.c. mains supply fails during boost conditions the two batteries shall be automatically connected in parallel by "no volt" contactors to the load.

It shall not be possible to connect a "boosted" battery to the load until its terminal voltage has fallen below the load equipment upper voltage limit.

14.8.3.4 Noise and Interference

To avoid unacceptable levels of electrical noise in the load equipment smoothing of the d.c. output is required. This shall achieve a psophometric noise level at the output, for loads between 0 and 100%, not exceeding the equivalent of 2 rnV at a frequency of 800 Hz after weighting as specified by ITU-T (CCITT).

The relative harmonic content of the input current shall comply with the European Directive for EMC, the EN 60555-2 standard. In the case of SMPS chargers active power factor correction (i.e. boost for step up converter) shall be provided to control the power factor.

The production of radio frequency interference voltages shall not exceed the values of suppression grade "N", as defined in EN 55014/55015 - for Thyristor-controlled type chargers, and suppression grade "B" as defined in EN 55022 for SMPS type chargers.

The performance of the d.c. power supply equipment unit shall not be affected, or in any way degraded, by the use of the following when the severity of the electromagnetic radiation environment corresponds to Class 3, in accordance with IEC 801-3:

- private mobile radio operating in designated or planned radio frequency bands
- current cellular radio equipment
- future cellular equipment
- mobile data equipment.

It is the Contractor's responsibility to determine the radio frequency bands applicable in the locality.

14.8.3.5 Efficiency/Rating

The charger efficiency shall not be less than 85%.

All chargers supplied shall preferably have the same rating, or be in fixed multiples, to limit the number of different charger ratings.

14.8.3.6 Instruments, Controls and Alarms

The charger shall be equipped with the following:

- a.c. mains input circuit breaker
- d.c. output circuit breaker
- charger output current meter
- charger output voltage meter
- alarms for charge fail, d.c. volts high etc.

Each alarm shall be provided with local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

14.8.4 Battery

14.8.4.1 Type

Nickel cadmium cells shall be of the pocket plate type in accordance with IEC 60623.

Cell containers shall be of the moulded plastic type, non-flame propagating and mechanically shock resistant. They shall provide for the electrolyte level to be viewed through the container material.

Cells shall be permanently marked with the following information:

- Manufacturer's reference number and code
- year and month of manufacture
- voltage and nominal capacity at C5 rate
- cell number.
- Cell Class-L

14.8.4.2 Mounting

The batteries shall be mounted on metal stands, or racks, in a manner such that all the plates of each cell are visible for inspection, test and maintenance purposes. Stands or racks shall have a maximum of two tiers. In all cases adequate space must be left between the tiers for maintenance purposes and to permit the topping up of electrolyte. Stands or racks shall have a protective finish of not less than two coats of electrolyte resisting enamel or gloss paint. Alternatively, an epoxy resin sintered finish may be used.

At locations where the battery is not housed in a separate battery room the battery stand/rack shall be fitted with cladding. The cladding shall permit the free flow of air to the battery, and shall be removable for maintenance purposes.

Cell containers shall be accurately set up in alignment on the stand or rack with lead and/or rubber discs under the feet moulded on each container. Cell lids shall be so positioned that at least one topping up aperture is on the access gangway side of the cell and not obstructed by any inter-cell connecting arrangements.

14.8.4.3 Battery Main Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated at five times the charger float output rated current. A cartridge fuse shall be provided in the charger input lead to the negative pole of the battery and rated at twice the charger float

output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. These fuse links shall comply with BS 88.

Class DC 40 or equivalent and shall be mounted in fuse carriers with an insulated barrier between the poles.

The cable or busbar to the battery shall be firmly supported at a point near the cell terminal pillar. Where two cables are used they shall be terminated one to either side of the terminal pillar. These cables shall be arranged as to allow some flexibility and to avoid any forces being applied to the cell terminal pillar.

14.8.4.4 Connections

The positive pole of each battery shall be connected to station earth via a single bolted link at the distribution cubicle. Low resistance inter-cell connectors shall be used. Connections between tiers of cells and between end cells and fuses shall be made with insulated copper rod which shall be of equivalent cross-section to the distribution busbars.

Connections from the battery fuses to the chargers and distribution cubicles shall be made with insulated cable of equivalent cross-section to the distribution busbars. The positive and negative terminals of each cell shall be clearly indicated. The positive and negative terminals of the complete battery shall be indicated by red and black marking respectively.

14.8.4.5 Capacity

The battery capacities shall be 250 ampere hours at C5 rate.

14.8.5 D.C. Distribution and Instrumentation

14.8.5.1 General

The distribution section shall be designed for incoming and outgoing d.c. supplies as follows:

- Two independent supplies (including one for future use) incoming from the batteries and associated chargers. The battery negatives shall be connected to the distributed busbar through a single pole switch. The 48V battery positive shall be

directly connected to the positive busbar.
- Each load equipment shall be connected to a distribution outlet. The use of teed supplies to more than one load equipment will not be permitted.
- Double pole miniature or moulded case circuit breakers to IEC 157 shall be supplied, fitted with auxiliary contacts which operate when the circuit breaker trips.

The MCBs shall be rated to meet the load requirements and shall be labelled with the destination of the load. Outgoing connections shall be brought to terminals, mounted in the cubicle, provided with strip connectors and cable lugs. The number of outlets shall cater for the quantity of load equipment items plus 50%, with a minimum of 10 outlets being provided, Space shall also be available for the installation of 10 extra outlets for future use.

14.8.5.2 Instruments and Alarms

Instrumentation shall comprise:

- battery ammeter (charge and discharge)
- battery voltage
- load current ammeter
- busbar voltage

An alarm indication shall be provided if the busbar voltage falls outside set limits.

The MCB auxiliary contacts and the high/low voltage alarm shall each provide local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

14.8.6 Housing

The above covers the mounting/housing for batteries.

A modular construction is preferred for the battery charger and d.c. distribution/instrumentation, with each unit comprising a single 19" or ETSI standard rack configuration, all mounted in a single cubicle.

The modular construction shall provide:

- simple plug in units for easy assembly and servicing
- individual battery charger unit removal in safety, without loss of output power to the

load.
- expansion of capacity at a later date

In the case of Contractors who do not offer a modular construction, separate cubicles are required for each charger and the d.c. distribution/instrumentation.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 15

QUALITY ASSURANCE, INSPECTION, TESTING, COMMISSIONING AND WARRANTY

SECTION 15

QUALITY ASSURANCE, INSPECTION, TESTING, COMMISSIONING AND WARRANTY

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SECTION 15

QUALITY ASSURANCE, INSPECTION, TESTING, COMMISSIONING AND WARRANTY

15.1 SCOPE OF SECTION

The whole of the plant covered by this Contract will be subject to inspection and witnessing the tests by the Employer during manufacture, erection and on completion. The inspection and witnessing the tests at manufacturer's works may be done by the Employer or an Independent Inspection agency. The approval of the Employer/Engineer or the passing of any such inspection or test will not, however, prejudice the right of the Employer to reject the plant if it does not comply with the specification when erected or when in service.

Within 40 days of the Letter of Acceptance for the Contract the Bidder shall submit a quality assurance programme and a work quality programme for the Engineer's approval. It shall be submitted on the Engineer's standard form, a sample of which is included at the end of this Section.

The Bidder shall have an approved Quality Management System complying with BS5750 Part 1 or CEN 209001, which shall cover all activities being undertaken during the design, procurement, manufacturing, inspection, testing, packaging, shipping, storage, installation and erection and commissioning of the Works.

After the award of Contract, the Engineer shall have the right to carry out a review of the quality assurance procedures operated by the Bidder. The Engineer's review may consider quality assurance in relation to the design and manufacture of plant items, but may equally investigate the Bidder's quality assurance procedures for the overall control of the wide range of design activities necessary for a complex project of this type, and the dissemination of paperwork, design drawings and data amongst the various design and manufacturing organisations within the Contract. The Bidder shall give all necessary help and assistance to the Engineer in carrying out such a quality assurance review. The Bidder shall consider and discuss the results of the review and make any reasonable improvements in his procedures.

Before any plant is packed or despatched from the Main or Sub Bidders' works, all tests called for shall have been successfully carried out in the presence of the Engineer unless otherwise agreed.

30 days notice shall be given when the plant is ready for inspection or tests and every facility shall be provided by the Bidder and his SubBidders to enable the Engineer and Employer to carry out the necessary inspection and witnessing of tests.

In the cases where tests or inspection are specified as being carried out on only a sample of the total quantity of items in the Works, and where one or more items of the sample fail the test or inspection, a further batch of the items, at least equal in quantity to the proportion originally specified, shall be tested or inspected. This process shall continue until a sample proves completely acceptable.

15.2 SUBCONTRACTS

Within two months of acceptance of the Bid and in order to facilitate the inspection of bought out materials and plant, the Bidder shall submit to the Engineer for approval

three copies of all suborders placed by him as soon as they are issued. One copy of any drawing or schedule referred to in the suborder shall be submitted simultaneously unless agreed otherwise with the Engineer. Any reference to price may be deleted from the copies so submitted.

The suborders and drawings submitted to the Engineer shall cover all components which are subject to electrical and mechanical pressure or stress when the plant is in operation and also auxiliaries and spares which are to be despatched to Site direct from the SubBidder's factory.

Suborders are to include a statement advising the SubBidder that the items being ordered will be subject to inspection and test by the Engineer and Employer.

The Bidder shall advise his SubBidders of all the pertinent clauses in the Specification when ordering bought out plant, equipment or materials.

Every suborder or subcontract shall contain the following information:

(a) Main Bidder's name and suborder or subcontract number.

(b) Quantities and description of work.

(c) Delivery requirements.

(d) Delivery consignment instructions.

(e) Details of Employer and/or main Bidder's applicable drawing or schedule numbers.

(f) Name of the Engineer.

(g) A note advising that the plant or equipment which is the subject of the order shall comply in every respect with the Engineer's, Specification and shall be subject to inspection by the Engineer, Employer and the Bidder.

(h) A reference, particularised in the accompanying Specification, covering the following information:

Employer's name Project title

Contract No.

Engineer's reference number

SubBidders shall comply with all the applicable requirements of this Specification and the onus is upon the Bidder to ensure that SubBidders comply with these requirements.

For the purposes of this clause, interworks orders shall be treated as suborders.

15.3 GUARANTEES

The Bidder shall state and guarantee the technical particulars listed in the Technical Schedules and other sections as specified by the Contract for testing procedures. These guarantees and particulars shall be binding and shall not be departed from without the written permission of the Engineer. The Bidder shall further guarantee that all equipment supplied complies with the Contract Documents.

The tolerances permitted in the IEC and British Standards shall apply unless otherwise stated.

15.4 QUALITY AUDIT

The Quality Programme established by the Bidder shall be followed for all inspection and testing procedures.

The Engineer and Employer may, from time to time, visit the manufacturer to carry out a quality audit of the manufacturer's organisation.

15.5 MEASURING AND TESTING EQUIPMENT

At prescribed intervals, or prior to each use, all measuring and testing equipment used in inspection shall be calibrated and adjusted against certified equipment having a known valid relationship to internationally recognised standards.

The manufacturer shall prepare a calibration schedule showing equipment type, identification number, location, frequency of checks, method of checking and action to take when results are unsatisfactory.

15.6 INSPECTION PLAN AND PROCEDURE

The Inspection Plan, as submitted by the Bidder to the Engineer for approval, shall cover the following:

(a) Relevant British Standards or equivalent International Standard. For each of the following stages of the work, the acceptance criteria shall be stated.

(b) The stages of inspection which shall include but not be limited to the following:

i) Tests to review or approve certification of material;

ii) Review and approval of manufacturing procedures;

iii) Witnessing tests or review and approval of certification of operator's qualification to carry out the work required;

iv) Visual and dimensional examination of components;

v) Pressure tests on casings and vessels;

vi) Nondestructive examination of materials in progress;

vii) Functional tests on subassemblies, performance tests, type tests on complete units;

viii) Examination of painting, packing and documentation for shipment.

The Engineer will indicate the inspection requirements on the agreed inspection programme in accordance with the following.

Hold point Requires a mandatory inspection by the Engineer. This inspection or test shall be witnessed by the Engineer and Employer and further progress in manufacture shall not be made until the plant is approved by the Engineer.

Witness point Inspection or test of material may be carried out by the Engineer and Employer at their discretion.

Document review Certification of material and functional test shall be approved by the Engineer before despatch from the works.

15.7 TEST CERTIFICATES

Triplicate sets of all test records, test certificates and performance curves, whether or not they have been witnessed by the Engineer and Employer, shall be supplied to the Engineer for all tests carried out in accordance with the provisions of this Contract.

Sets of all test certificates shall be endorsed with sufficient information to identify the material or equipment to which the certificates refer, and shall carry in the top right hand comer the following reference:

Employer's name

Project title

Contract No.

Engineer's reference number

All test documentation shall be in the English language.

15.8 MATERIAL TESTS

The Bidder shall provide test pieces as required by the Engineer to enable him to confirm the quality of the material supplied under the Contract. Such test pieces shall be prepared and supplied free of charge and any cost of the tests shall be borne by the Bidder.

If any test piece fails to comply with the requirements of the appropriate specifications for the material in question, the Engineer may reject the whole of the material represented by that test piece; the Bidder's or SubBidder's designers and metallurgists will be consulted before any material is to be so rejected.

If the Engineer is furnished with certified particulars of tests which have been carried out for the Bidder by the suppliers of material, he may, at his own discretion, dispense with the previously mentioned tests.

15.9 GENERAL REQUIREMENTS FOR TESTS AT MANUFACTURERS' WORKS

15.9.1 Testing of Plant

Tests at manufacturers' works shall include mechanical, electrical and hydraulic tests to ensure that the plant being supplied complies with the requirements of the Specification.

Works tests shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant IEC or British Standards, except where departures therefrom and modifications thereto are embodied in this Specification.

Should the plant or any portion thereof fail under test to give the required performance, further tests which are considered necessary by the Engineer shall be carried out by the Bidder and the whole cost of the repeated tests borne by the Bidder. This also applies to tests carried out at the SubBidders' works.

The Employer or its representative or independent inspection agency may witness the tests. Sufficient notice (minimum of 30 working days) shall be given to enable the necessary arrangements to be made.

If the plant, or any portion thereof, fails under test to give the required performance,

such further tests which are considered necessary by the Engineer shall be carried out by the Bidder and the whole cost of the repeated tests shall be borne by the Bidder. This also applies to tests carried out at SubBidders' works.

Tests shall be conducted in accordance with the specified standards. When no standards are specified, the test procedure shall be agreed between the Employer and the Bidder.

Specific details of tests to be carried out at the manufacturers' works are defined elsewhere in this Specification.

15.9.2 Rejection of Plant

If any item fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at Site, the Engineer may reject the item, or defective component thereof, whichever he considers necessary, and after adjustment or modification as directed by the Engineer, the Bidder shall submit the item for further inspection and/or test.

In the event of a defect on any item being of such a nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Bidder, at his own expense, to the entire satisfaction of the Employer.

15.10 SPECIFIC REQUIREMENTS FOR TESTS AT MANUFACTURER'S FACTORIES

15.10.1 Pressure Vessels

(a) All pressure vessels shall be designed, fabricated, inspected and tested in accordance with an approved pressure vessel code or standard.

(b) An approved method of radiographic or other nondestructive testing shall be used for proving all welding, at all positions of possible high stress concentration, such as large branch welds, and their vicinities after all heat treatment is completed. This shall be done whatever the programme of nondestructive testing before heat treatment.

(c) Hydrostatic test shall be conducted in accordance with BS 5500.

15.10.2 Deleted

15.10.3 Relays

All relays and associated equipment shall be routine tested to prove the quality and accuracy. Routine tests shall be in accordance with relevant IEC Recommendations and BS 142:1966, supplemented by additional tests as are considered necessary by the Employer. Routine test reports shall be submitted for each relay and piece of equipment. The reports shall record all measurements taken during the tests.

All relays shall be subjected to the appropriate routine tests as listed below, the individual tests being as detailed in IEC 60255 or as otherwise agreed with the Employer.

(a) Accuracy of calibrated pickup and dropoff levels over the effective range of settings

(b) Insulation tests

(c) Accuracy of timing elements

(d) Correct operation of flag (or other) indicators

(e) Mechanical requirements, integrity/safety of drawout units, check of contact pressure and alignment.

15.10.4 Instrument Transformers

Current transformers for differential protection shall be routine tested as sets.

(a) Short time current test

(b) Temperature rise tests

(c) Impulse voltage test

All instrument transformers shall be routine tested as per clause 15.10.12.

15.10.5 Electrical Instruments and Meters

One instrument and meter of each type and rating shall be subjected to the tests as specified in IEC 60051.

15.10.6 AC Switchboards

Routine tests shall include general inspection and electrical operation tests.

15.10.7 Contactors

One contactor of each type and rating shall be subjected to type tests as specified in IEC 60292 1.

15.10.8 PVC Cable

Each size and rating of PVC cable shall be subjected to type tests as specified in BS 6346. Routine tests are detailed in Section 5 of this document.

15.10.9 Switchgear (Other than GIS)

Routine tests in accordance with IEC 60056 shall be carried out on all circuit breakers.

15.10.10 Disconnectors and Earth Switches

Routine tests to IEC 60271-102 for switch disconnection.

15.10.11 Deleted

15.10.12 Current and Voltage Transformers

Routine tests to IEC 60044-1 and IEC 60044-5.

15.10.13 Structures of Electrical Equipment

Sample tests on the assembly and galvanising of the structures shall be carried out. A mechanical type test with the structure loaded with working load multiplied by the appropriate factor of safety shall be carried out.

15.10.14 Surge Arresters

Routine tests to the specified standards shall be carried out.

The following routine tests shall be carried out on all arrester units in accordance with IEC 600994.

(a) measurement of reference voltage

(b) residual voltage test

(c) partial discharge test

(d) housing leakage test

(e) current distribution test for multicolumn arrester.

The following acceptance tests shall be carried out on one complete arrester of each voltage rating and/or type being supplied, all in accordance with IEC 600994.

(a) measurement of power frequency voltage at reference current

(b) lightning impulse residual voltage at nominal discharge current

(c) partial discharge current

(d) accelerated ageing test followed by an operating duty test details are to be agreed with the Engineer.

15.10.15 Batteries and Battery Chargers

Battery -The Bidder shall demonstrate that the battery will perform the duties specified.

Battery Charger - Routine tests according to IEC 60146 (BS 4417)

DC Switchboard - Routine tests according to IEC 60439 (BS 5486:Part 1)

Complete charge and discharge tests on each of the combined batteries and chargers shall be conducted and results recorded so as to permit verification of the amperehour capacity of the battery. During these tests the Engineer shall select at random reference cells and the voltage curves thereof shall be checked when the battery is discharged over three and five hour periods. The alarm levels and the automatic voltage control feature of the charger shall be demonstrated over the specified load range. Where load changeover facilities are included, integrity of the changeover system without break or voltage variations during loading of the standby or test charger shall be demonstrated.

15.10.16 Control Panels

Routine operation tests and insulation resistance tests shall be carried out.

15.10.17 Busbars (other than GIS)

Routine tests including millivolt drop tests shall be carried out in accordance with the specified standard.

15.10.18 Instruments

Calibration tests shall be witnessed on all important pressure gauges and other instruments as required by the Engineer.

15.10.19 Neutral Earthing Resistor

Routine leakage and over voltage tests.

Bushing insulator wet flashover tests (internal and external).

15.10.20 Power Transformers

Inspection and testing during manufacture shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant IEC Standard, except where departures therefrom and modifications thereto are embodied in this Specification. For Plant not covered by any IEC Standard or specifically mentioned in this Specification, such tests as are relevant shall be agreed with the Engineer.

Should the Plant, or any portion thereof, fail under test to give the required performance, further tests which are considered necessary by the Engineer shall be carried out by the Bidder and the whole costs of the repeated tests borne by the Bidder. This also applies to tests carried out at the SubBidders' works.

After satisfactory completion of the witnessed tests at the Works, the Plant shall be submitted for the Employer's approval during dismantling preparatory to shipment. No item of Plant is to be despatched to Site until the Employer has given his approval in writing.

15.10.20.1 Main Transformers

Routine Tests

All transformers shall be subject to the following routine tests in accordance with IEC 60076 and the requirements of this Specification.

i) Measurement of winding resistance on all tap positions and phases.

ii) Ratio, polarity and phase relationship.

iii) Impedance voltage.

iv) Load loss at normal, maximum and minimum taps.

v) No load loss and no load current at normal voltage Un and at +5% Un and at +10% Un.

vi) Magnetising current at nominal voltage Un and at 5% Un and +5% Un and at +10% Un.

vii) Insulation resistance.

viii) Dielectric Withstand Tests:

- On uniformly insulated windings with highest voltage Um = 36kV, tests shall comprise:

(a) induced over voltage withstand.

(b) short duration power frequency voltage withstand.

(c) full wave lightning impulse withstand for line terminals.

(d) lightning impulse chopped wave at 115% of the full wave level.

- On nonuniformly insulated windings with highest voltage Um 145 W, tests shall comprise:

(a) induced over voltage withstand combined with partial discharge.

(b) short duration power frequency voltage withstand.

(c) full wave lightning impulse withstand for line terminals.

(d) lightning impulse chopped wave at 115% of the full wave level.

- On nonuniformly insulated windings with highest voltage Um = 245kV, tests shall be carried out according to a combination of methods 1 and 2 and comprise:

(a) short duration power frequency voltage withstand.

(b) induced line to earth overvoltage withstand test at 460kV (method one routine test).

(c) full wave lightning impulse withstand for line terminals.

(d) lightning impulse chopped wave, at 115% of the full wave level.

(e) induced power frequency overvoltage withstand test with partial discharge measurement.

This shall be performed in symmetrical threephase connection on completion of all the above tests. The time sequences and test levels shall be:

U2 (1.5Um/1.732 with Q = 500pC) 5 minutes duration

U1 (Um) 5 seconds duration

U2 30 minutes duration

ix) Insulation Resistance

Type Tests

i) Temperature rise test:

The test shall be in accordance with IEC 60076-2, and shall be carried out on one transformer of each size and type. Temperaturerise tests shall be conducted on the tapping corresponding to the maximum losses.

ii) Noise level tests:

A noise level test to IEC 60076 shall be carried out on one transformer of each type specified under items 1 and 2 in accordance with IEC 60551**.**

Special Tests

i) Measurement of Zero Phase Sequence Impedance:

The test shall be in accordance with IEC 600761 Clause 8.7 and shall be carried out on one transformer of each type.

15.10.20.2 Voltage Control Equipment

Routine Tests

Each finished tap changer shall be subjected to the routine tests specified in IEC 60214 but in addition the mechanical test shall be carried out at rated voltage and no load.

Type Tests

Shall be carried out entirely in accordance with IEC 60214 except that evidence of the service duty type test shall be in excess of 100,000 operations.

15.10.20.3 Magnetic Circuit

Routine Tests

Each core completely assembled shall be tested for one minute at 2,000V AC between core bolts, side plates, structural steelwork and core at the core and coil stage. After the transformer is tanked and completely assembled, a further test shall be applied between the core and the earthed structural steelwork to prove that the core is earthed through the removable link, at one point only.

15.10.21 Outdoor Bushing Assemblies with Porcelain Insulators

Hollow insulators tested in accordance with IEC 60233

Complete bushings tested in accordance with IEC 60137

Routine Tests

To include:

i) Oil leakage test

ii) 50Hz dry withstand test

iii) Power factor/voltage test

iv) Partial discharge test on all bushings of which the major insulation is either oil impregnated paper or resin impregnated paper.

15.10.22 Tanks

Routine Tests

Oil Leakage:

All tanks, conservators and oil filled compartments, which are subjected in service or during maintenance to oil pressure, shall withstand without leakage a hydraulic pressure test equal to

69kN/m^2 or the normal pressure plus 34kN/m^2 whichever is the greater, for 24 hours during which time no leakage or oil ingress into normally oil free spaces shall occur.

15.10.23 Cooling Plant

Routine Tests

(a) Coolers: Pressure test to be as specified above.

(b) Motors and Control Gear: To the requirements as specified.

15.10.24 Gas and Oil Actuated Relays

Routine Tests

(a) Oil Leakage:

When subject to an internal oil pressure of 207kN/m^2 for fifteen minutes.

(b) Gas Collection

(c) Oil Surge

(d) Performance test under service conditions

(e) Voltage: 2kV for one minute between electrical circuits and casing.

15.10.25 Galvanizing

Routine Tests

To the requirements of BS 443 or BS 729 whichever is applicable,

15.10.26 Earthing Transformers

Routine Tests

(1) Measurement of Winding Resistance

(2) Ratio, polarity and phase relationships

(3) Measurement of impedance voltage

(4) Measurement of loss

(5) Short duration power frequency voltagewithstand test

(6) Induced overvoltage withstand test

(7) Insulation resistance of each winding

Special Tests

(1) Measurement of zerophase sequence impedance

15.10.27 Fibre Optic Multiplexer Equipment

Works tests shall be in accordance with the IEC standard

15.10.28 Deleted

15.10.29 Telephone Equipment

Comprehensive system testing including subscriber to subscriber tests with transit working shall be carried out with the exchanges fed from normal, high and low volts. Hunting, alternative routing and priority facilities, etc., shall be checked.

15.10.30 Teleprotection Equipment

Back to back tests shall be carried out to determine the satisfactory operation of the teleprotection equipment.

These tests shall be via fibre optic multiplexer equipment links, simulated lines or communication channels dependent on the actual application.

Random tests shall be performed which demonstrate to the Engineer the ability of the equipment to operate satisfactory (reliability) and within the specified time limits (speed) in the presence of interfering signals or noise and also the ability not to malfunction (security) in the presence of interfering signals or noise at levels likely to

occur when the equipment is installed in the power system substations.

15.10.31 Transducers

Transducers shall be tested in accordance with IEC 606881.

15.11 DISMANTLING PRIOR TO SHIPMENT

After the satisfactory completion of all tests at the factory, the plant shall be submitted for the Engineer's approval during dismantling preparatory to shipping. No item of plant shall be despatched to site until the Engineer has given approval in writing.

15.12 INSPECTION AND TESTING DURING SITE ERECTION

15.12.1 General

The Bidder shall be responsible for the submission to the Engineer of all plant supplied under the Contract for inspection and testing during site erection, to ensure correct erection and compliance with the Specification.

During the course of erection, the Bidder shall provide access as required by the Engineer for inspecting the progress of the works and checking its accuracy to any extent that may be required.

The Bidder shall provide, at his own cost, all labour, materials, stores, and apparatus as may be requisite and as may be reasonably demanded to carry out all tests during erection, whether or not the tests are specifically referred to in this specification.

Tests on completion of erection shall be carried out by the Bidder in accordance with the General Conditions of Contract. The Bidder shall provide all necessary test equipment to carry out the site tests, but where required in the Schedule of Prices, shall include the cost of the equipment so that the Employer may have the option to buy the equipment on completion of the Contract.

The Bidder shall submit a written programme of tests and checks according to this Clause for the approval of the Engineer.

A brief description of all tests and testing procedures shall be provided before tests commence and the method of testing, unless otherwise specified, shall be agreed with the Engineer.

The Bidder shall provide experienced test personnel and testing shall be carried out during normal working hours as far as is practicable. Tests which involve existing apparatus and outages may be carried out outside normal working hours. The Bidder shall give sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing programme.

The Bidder shall advise the Engineer in writing, at the time of commencement of site erection, of the site supplies which will be required for the operation of the test equipment, to enable the Engineer to arrange accordingly or to agree alternative arrangements should this be necessary.

The Bidder shall record the results of the tests clearly, on an approved form and with clear reference to the equipment and items to which they refer, so that the record can be used as the basis for maintenance tests during the working life of the equipment. The required number of site test result records shall be provided by the Bidder to the Engineer as soon as possible after completion of the tests.

No tests as agreed under the programme of tests shall be waived except upon the instruction or agreement of the Engineer in writing.

The Bidder's test equipment shall be of satisfactory quality and condition and, where necessary, shall be appropriately calibrated by an approved authority at the Bidder's expense. Details of the test equipment and instruments used shall be noted in the test sheets in cases where the instrument or equipment characteristics can have a beating on the test results.

The testing requirements detailed under this Specification may be subject to some variation upon the instruction or agreement of the Engineer where necessitated by changed conditions at Site or by differing design, manufacture, or construction techniques.

The Bidder is required to submit proposals for site dielectric tests and to include in his price the costs of such tests and of such equipment as deemed necessary.

15.12.2 Mechanical Equipment

The extent of testing during erection shall include, but not be limited to, the following:

(a) Checking the accuracy and alignment of plant erected. The accuracy shall comply with the relevant standards, the specification or the plant manufacturer's requirements as may be applicable or, where no requirements exist, to a standard to be agreed between the Engineer and the Bidder.

(b) Checking the alignment of rotating equipment to the manufacturer's requirements.

(c) Nondestructive testing of site welds as required by the relevant standard and as detailed in this specification.

(d) Hydrostatic testing of pipework systems at a pressure of 1.5 times the design pressure but not less that 4.5 bar for a period of 2 hours, or at such other conditions as may be required by the pipework design code.

Air piping shall be subjected to an air pressure test rather than a hydrostatic test.

(e) Site fabricated tanks and vessels shall be subjected to hydrostatic tests in accordance with the relevant standards.

(f) Hydrostatic tests shall be carried out on steam generating units in accordance with the boiler design code.

After the hydrostatic test is carried out, the complete assembly shall be drained and any nondrainable sections shall be injected with an oxygenabsorbent chemical and elements plugged.

(g) Pressure vessels and other parts, including pipework, that are made up on site and are subject to pressure or vacuum under normal or abnormal working conditions, shall be subjected to a site hydraulic test at approved pressures and for approved periods in accordance with the relevant standard. Where no appropriate standard exists the hydraulic test pressure shall not be less than 1.5 times design pressure or at such pressure to be agreed by the Engineer.

Should, in the opinion of the Bidder and with the agreement of the Engineer, an hydraulic test be impracticable due to excessive loading on foundations other than

steel, an air pressure test may be employed in accordance with requirements set out in BS 5500.

Vacuum tests shall be carried out at the maximum test vacuum obtainable and the condition maintained for a period of two hours with the system isolated. The Bidder shall state in the Schedule of Guarantees the fall in vacuum anticipated during this period but the rate of fall shall not exceed that which would occur due to the designed air leakage rate being attained.

(h) Calibration checks on all instrumentation.

(i) Tests to demonstrate the correct functioning of the control loops, protective devices, interlocks and alarms.

Flushing out of all pipework systems which have not been fully cleaned and sealed before shipping to site.

(k) Other tests as specified which have not been previously conducted.

15.12.3 Electrical Equipment

15.12.3.1 General

A general check of all the main switchgear and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, labelling, arcing ring and horn gaps, clearances, painted surfaces, cables, wiring, pipework, 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 which are to be handed over to the Employer e.g. blanking plates, tools, spares, are in order and are correctly stored or handed over.

The following general tests are to be carried out on electrical equipment after erection at site:

(a) Routine high voltage tests to the appropriate IEC Standard. Where no relevant standard exists, tests shall be agreed with the Engineer.

(b) Insulation resistance tests on all electrical equipment.

(c) Continuity and conductivity resistance tests.

(d) Test operation of alarm and tripping devices from local and remote location.

(e) Rotational tests on all motors.

(f) Polarity tests on CTs and VTs.

(g) Oil tests.

(h) Grounding system and electrode tests.

(i) Ratio, Vector Grouping and magnetising current tests on each transformer.

0) Calibration of winding and oil temperature devices.

(k) Vector group and phasing tests on VT circuits.

(l) Magnetisation current/voltage tests and winding resistance tests on all current transformers.

(m) Primary and secondary injection tests on relays, protection devices and equipment.

15.12.3.2 Circuit Breakers

Circuitbreakers shall be given a visual inspection.

In the case of gas type circuitbreakers testing will be required on the gas system to prove the gas pressure, quantity, dryness and dielectric strength.

Contact resistance tests shall be carried out. In the case of multiinterrupter circuitbreakers resistance tests will be required at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Operational tests shall include local and remote trip/close. Timing tests shall be carried out on all circuitbreakers, except those which are below 66kV and which are neither assembled at Site nor have mechanically ganged pole operation.

Local air components associated with pneumatic operation, including air compressors, shall be tested and air loss measurements and pressure and alarm settings checked. Tests shall be made also on mechanical and hydraulic operating systems.

15.12.3.3 Disconnectors and Earth Switches

Manual operation of disconnectors and earth switches shall be subject to operational tests to confirm contact pressures, contact resistances, simultaneous operation of all phases and the ease of operation.

Motorised operation of disconnectors, and earth switches shall be tested to prove the motor operation, including local and remote operation, and timing tests shall also be carried out. Motor protection shall be tested.

Checks shall be made on interlocks, local and remote indications and operation of auxiliary contacts.

Earth switches shall be tested to confirm the opening and closing sequences and checks shall be made on interlocks, indications and manual locking devices.

15.12.3.4 Busbars and Connections

Flexible busbars and 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.

Rigid busbars and connections shall be tested to ensure that the busbars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the site and that expansion and contraction of the equipment is fully accommodated by flexible connections.

Conductivity tests shall be carried out on all connections and joints which are made on site, without exception.

15.12.3.5 Earthing System

Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid possible corrosion attack on the earthing system.

Test probes at approximately 300 and 600 metres separation will normally be required to effectively test the earthing system. The use of transmission line conductors may be arranged to simplify these testing procedures.

The earth resistance shall be measured during the installation and on completion as follows:

(a) of each earth rod after driving

(b) of the earth grid after completion and backfilling of the trenches

(c) of each group of earth rods or earth point after completion of the connection from the test link terminal

(d) of the completed installation without any connections outside the substation

The tests shall be carried out by a method and with equipment approved by the Engineer. All tests are to be witnessed and the equipment and method used recorded with the test results.

The Bidder may also be called upon to provide assistance in the measurement of earth resistance after earth connections to the system have been completed.

15.12.3.6 Control Relays and Metering Panels, Instruments and Protective Devices

(a) Wiring

After complete erection and cabling, all circuits shall be subjected to the high voltage test specified in the relevant IEC or approved standard.

The insulation resistance of all circuits shall be measured before and after any high voltage tests.

For AC secondary injection tests a substantially sinusoidal test supply shall be used.

The operating and resetting level (current and/or voltage) and timing of all relays shall be measured over an agreed range of settings for all relays.

For directional relays phaseshifting transformers shall be used to determine the maximum torque angle and the boundaries of operation/restraint.

Other relays shall be fully tested in accordance with the manufacturer's recommendations.

All DC elements of protection relays shall be tested for operation at 70% rated voltage.

All DC supplies shall be checked for severity of current inrush when energised by switching on or inserting fuses or links.

(b) Mechanical Inspection

All panel equipment is to be examined to ensure that it is in proper working condition

and correctly adjusted, correctly labelled and that cases, covers, glass and gaskets are in good order and properly fitting.

(c) General

Sufficient tests shall be performed on the relays and protection schemes to:

i) establish that the equipment has not suffered damage during transit.

ii) establish that the correct equipment has been supplied and installed.

iii) confirm that the various items of equipment have been correctly interconnected.

iv) confirm performance of schemes designed on the bases of calculation e.g. differential protection.

v) to provide a set of figures for comparison with future maintenance values

allowing the condition of the equipment to be determined.

(d) Secondary Injection

Secondary injection shall be carried out on all AC relays, using voltage and current of sinusoidal wave form and rated power frequency to confirm satisfactory operation and range adjustment.

The polar characteristic of all distance protections shall be recorded at a minimum of 30 degree intervals.

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 fault setting for the type of protection is to be established by secondary injection, where it is impracticable 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 CT's connected.

(e) Primary Injection

All current operated relays shall be tested by injection of primary current to record the actual relay setting and as a final proof of the integrity of all secondary connections.

The stability of all differential schemes shall be checked by injection of primary current.

Primary current injection tests are to be carried out by the Bidder and the methods employed for a particular installation are to be agreed with the Engineer.

Tests are to be carried out as follows

i) Local primary injection to establish the ratio and polarity of current transformers as a group, care being taken to prove the identity of current transformers of similar ratio.

ii) Overall primary injection to prove correct interconnection between current transformer groups and associated relays.

iii) Fault setting tests, where possible, to establish the value of current necessary to produce operation of the relays.

(f) DC Operations

Tests are to be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indications and alarms. The correct functioning of all isolation links and fuses shall also be checked.

(g) Tests on Load

Tests on load shall also be done to demonstrate stability and operation of protection relays as required by the Engineer.

All tripping, control, alarm and interlocking circuits shall be functionally tested to prove satisfactory and foolproof operation and/or resetting. The functional and safety aspects of all shorting and/or isolation links, fuses and switches devices shall be proved.

The total burdens connected to all voltage transformer circuits shall be measured and recorded.

The total capacitance of all wiring and apparatus connected to the negative pole of each main tripping battery shall be measured and recorded; the value shall not exceed 10 microfarad.

The continuous current drain of all trip circuit supervision relays shall be measured and shall not be greater than half the minimum current required for tripping. The supervision current shall be measured with the circuitbreaker (or other device) both open and closed.

15.12.3.7 Batteries and Chargers

Tests shall be carried out on the batteries and chargers to confirm the charger ratings and adjustment, the battery and charger alarm systems and battery capacity.

The open circuit cell voltages of the batteries when fully charged shall be recorded.

The insulation to earth of the complete DC installation shall be tested.

15.12.3.8 Power Cables

Each completed circuit shall be tested for continuity and insulation resistance.

15.12.3.9 Current Transformers

A magnetisation curve shall be obtained for each current transformer in order to:

(a) Detect damage in transit or installation

(b) Prove that the correct cores have been wired out to the relevant terminals

(c) For high impedance relay schemes, to confirm that correct relay settings have been calculated.

The DC resistance of each current transformer secondary winding shall be measured and also the transformers and connecting leads, each item being recorded separately.

The insulation resistance of all secondary circuits shall be measured at 1000 volt and recorded.

Primary current injection tests shall be conducted on all current transformers using

adequate primary current to prove correct ratio, polarity and, for differential protection schemes, to prove the correct relative polarities of all current transformers of each scheme.

15.12.3.10 Voltage Transformers

The transformer ratio and polarity shall be checked using a primary voltage high enough to give a clearly measurable secondary voltage or by using rated primary voltage and comparison with an already proven voltage transformer. The phasing and phase rotation shall be checked. For three phase voltage transformers a test shall be conducted to show that energising each primary winding produces an output from only the correct phase secondary winding. The residual voltage of any open delta or broken delta winding shall be measured with rated primary voltage applied.

15.12.3.11 Control and Instrumentation Equipment

The following general tests shall be performed on control and instrumentation equipment at site:

(a) High voltage testing of all circuits, as specified in the relevant IEC or approved standard.

(b) Insulation resistance testing of all circuits.

(c) Functional tests of all tripping, control, alarm and interlocking circuits.

(d) The testing of all equipment in accordance with the manufacturer's instructions or as advised by the Engineer.

15.12.3.12 Transformers and Ancillary Equipment

The following tests shall be performed.

i) Insulation resistance tests on bushings.

ii) Insulation resistance test at 500V between core and core clamping structure.

iii) Voltage withstand tests on insulating oil to BS 148.

iv) Ratio.

v) Phase relationship.

vi) Magnetisation characteristics of current transformers of winding temperature devices.

vii) Calibration of winding temperature devices.

viii) Tap Selector and Diverter Switch alignment.

ix) Calibration of automatic voltage control equipment.

x) Proving tests as necessary on control schemes.

xi) Measurement of winding resistance on all taps and phases.

Where applicable the above tests shall also be carried out on Earthing Transformers.

15.12.3.13 FOX, Teleprotection and Communication

Tests shall be exhaustive and shall demonstrate that the overall performance satisfies every requirement specified.

The tests to be carried out shall be:

(a) Physical inspection unit testing and demonstration of diagnostic aids as appropriate of al equipment in stand alone mode.

(b) System testing of 48V power supply equipment.

(c) System testing of FOX equipment for speech and teleprotection.

(d) System testing of telephone equipment.

(e) System testing of teleprotection equipment to plant.

15.13 STAFFING

During precommissioning the Bidder shall provide all necessary supervisory and operating staff. The only involvement of the Employer's staff will be in accordance with the training and instruction as in this specification.

During the commissioning phase, the Employer's operating staff will operate plant and equipment under the supervision of the Bidder's supervisors.

The Bidder shall have satisfied himself as to the capability of the Employer's operators to carry out such operations as he may direct and shall remain responsible for the successful performance of such operations. Throughout the whole of the Commissioning Period the Bidder shall provide suitably qualified and experienced operating staff, who shall instruct the Employer's staff in the correct operating procedures.

The Bidder shall provide a team of suitably qualified and experienced engineers and technicians to precommission and commission the overall plant. The Bidder shall also ensure that a suitably qualified commissioning engineer from the respective manufacturer's own service organisation shall visit the site to check the erection or installation of each significant plant item, and to supervise the commissioning of the plant item until the basic functioning of the item has been demonstrated to the Engineer's satisfaction.

At all times the Bidder shall ensure that his staff and any SubBidder's or seconded staff, observe all prescribed safety rules and permit systems.

15.14 TAKING OVER

After satisfactory completion of the tests on completion, the Engineer will issue a Taking Over Certificate for the plant. The issue of any such certificate shall not however relieve the Bidder of any of his responsibilities in respect of proving that the performance of the plant meets the guaranteed values.

The Taking Over Certificate shall make reference to a schedule of outstanding minor defects and omissions which have been accepted by the Engineer as not affecting the full and safe operation of the plant. The Bidder shall rectify such defects and omissions not later than 3 months after Taking Over.

The date certified in the Taking Over Certificate shall be the date on which the tests on completion were completed.

15.15 DEFECTS AFTER TAKING OVER

In accordance with the General Conditions of Contract, the Bidder shall be responsible for making good defects or damage which may appear or occur during a 12 month guarantee period from the date certified in the Taking Over Certificate.

Following any remedial work or replacement of any component part during the 12 months, the guarantee period for such a part shall be extended, commencing from the date at which the remedial work was completed.

Immediately prior to the completion of this period the Employer reserves the right to request the Bidder to open up for inspection the whole or any part of the Plant. The Employer will provide the labour to work under the direct supervision of the Bidder's representative for the purpose of such inspection.

The Bidder shall submit for approval the arrangements he intends making under this Contract for the making good of defects and for providing the supervisory service detailed above.

15.16 FINAL ACCEPTANCE CERTIFICATE

Application for the Final Certificate may be made to the Engineer after the Bidder has ceased to be under any obligation under the Contract. This shall include the submission of final contract record drawings and fully bound version of the Installation, Operation and Maintenance Manuals. If a TakingOver Certificate has been issued in respect of any Section or Portion of the Works, only one Final Certificate will be issued after all the said obligation has ceased. Final Certificate will be issued after all the said obligation has ceased. Where the Bidder has carried out replacements or renewals to the Works, the Bidder's obligations shall continue, but the right of the Bidder to apply for a Final Certificate other than for the replacements or renewals shall not be affected by that fact.

SECTION 15
APPENDIX A

REF. N0.	ITEM OR COMPONENT	PROC-ESS	DESCRIPTION OF OPERATION	DOCUMENT-ATION	SPECIFICATIONS/STANDARDS	PROG	ACTION BY		
						DATE			
							BIDDER	EPL	THIRD PARTY
Quality Assurance &			Project Title: Job No. Client: Contract No: Bidder Contract No:			Legend XI Hold Point X2 Witness Point X3 Record Review QAS QA Surveillance		Note Certification Requirements Note Any Other Requirements	

Inspection Dept.	Author: Date	Checked by:			Approved by:	
						QUALITY PLAN
	Rev.No/Date	1	2	3	4	Number: Sheet
	Revision					

SECTION 15
APPENDIX B

NOTIFICATION OF WORKS INSPECTION

To facilitate the handling of inspection notifications, the following procedure shall be observed.

At the commencement of all contracts, discussions shall be held with the Main Bidder's nominated representative and the Engineer to establish guidelines for the handling of inspection notifications and test documentation.

The Main Bidder shall prepare a notification form which shall include, but not necessarily be limited to, the following:

1 . INSPECTION NOTIFICATION NUMBER

2. PROJECT TITLE

3. MANUFACTURER AND FULL ADDRESS

4. WHERE TEST/INSPECTION WILL BE CARRIED OUT
(IF DIFFERENT FROM 3 ABOVE)

5 ORDER/SUB ORDER NUMBER

6 CONTACT NAME

7 FAX/TELEPHONE NUMBER

8 DETAILS OF EQUIPMENT TO BE TESTED/INSPECTED AND WHETHER EQUIPMENT IS COMPLETE

9 SCHEDULE OF TESTS

10 MANUFACTURER'S APPROVED DRAWING NUMBER AND CORRESPONDING MEP NUMBER

11 DATE OF INSPECTION

The Main Bidder shall be responsible for recording all inspection notifications in numerical order and shall submit copies of the appropriate record at monthly intervals to the Inspection Department.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 16 (Not Applicable)

WORKS AND EQUIPMENT FOR SHUNT REACTOR INSTALLATION

SECTION 16

(NOT APPLICABLE)

WORKS AND EQUIPMENT FOR SHUNT REACTOR INSTALLATION

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SECTION 16

WORKS AND EQUIPMENT FOR SHUNT REACTOR INSTALLATION

16.1 SCOPE

These clauses describe the General Technical Requirements for 400kV Shunt Reactor and associated switchgears including all necessary works and services for installing Shunt Reactor and associated switchgears at 400KV substation and shall be read in conjunction with the Requirements in Volume 2 of 3 if necessary after EMTP study (study to be performed by the contractor) and size of the above reactor shall be based on the above study report.

The scope of works may include based on study report as follows:

- 400 kV, size based on EMTP study report, three phase outdoor type Shunt Reactor as specified in the technical specifications of this Section

- 420kV, 800A, 63kA/1sec, 50Hz, 1425kVp BIL, live tank type, gang operated, SF6 gas circuit breakers with spring-stored energy operating mechanism as specified in the technical specifications, Section 3, Volume 2 of 3 of the Bidding Document

- 420kV, 800A, 63kA/1sec, 50Hz, 1425kVp BIL, horizontal double break, post type, motor operated disconnectors without earthing switch as specified in the technical specifications, Section 3, Volume 2 of 3 of the Bidding Document

- single-phase, 5-core, 420kV, 63kA/1sec, 800A, 50Hz, 1425kVp BIL, Bushing type current transformer as specified in the technical specifications, Section 3, Volume 2 of 3 of the Bidding Document

- Control, Protection, Monitoring & Substation Automation System including event recording function for Two (2) sets of Shunt Reactor line circuits as specified in the technical specifications and bid drawings (refer to drawing of Volume 2 of 3 of the Bidding Document)

- One (1) lot of rigid tubular bus [Aluminium of grade 63401 WP], flexible conductors, insulators, fittings including all necessary clamps and connectors required for completing the connection of Shunt Reactor with the line as specified in the technical specifications and bid drawings (refer to drawing of Volume 2 of 3 of the Bidding Document)

- One (1) lot of steel structures for gantry, equipment supports and civil works required for completing the connection of Shunt Reactor with the line as specified in the technical specifications and bid drawings (refer to drawing of Volume 2 of 3 of the Bidding Document)

The Bidder is bound to provide complete works, even if the equipment or services to

be provided are not specifically mentioned in the specification.

The supply and services to be performed by the Bidder shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning and warranty of the works.

“Installation, testing & commissioning of Shunt Reactor shall be done by the Shunt Reactor engineer(s) of the Shunt Reactor manufacturer(s).”

16.2 REFERENCES

16.2.1 IEC Standards

IEC 60044 Instrument transformers-Part 1: Current transformers
IEC 60044 Instrument transformers-Part 2: Inductive volatage Transformers
IEC 60060 High voltage testing techniques (Part 1 & 2)
IEC 60076 Power transformers (Parts 1, 2, 3, 4, 5, 6, 7, 8 & 10)
IEC 60137 Insulated bushings for alternating voltages above 1000V
IEC 60296 Specification for unused mineral insulating oils for transformers and switchgear
IEC 60422 Supervision and maintenance guide for mineral insulating oils in electrical equipment
IEC 60529 Degrees of protection provided by enclosures
IEC 60815 Guide to the selection of insulators in respect of polluted condition

16.3 SHUNT REACTOR

16.3.1 General

Shunt reactors shall be outdoor, oil-immersed, three-phase type. They shall comply with the requirements of the schedules and standards listed above and other relevant IEC standards.

The shunt reactors shall be suitable for continuous operation on a three-phase 50 Hz high voltage transmission system at the maximum system voltage as specified in the Technical Schedules.

Shunt reactors and associated equipment shall be designed in such a manner as to meet the requirements in this section, Technical Schedules and Drawings at ambient site conditions.

Shunt reactors shall meet the latest stage of development reached in design, construction and materials.

The shunt reactors and all associated facilities shall have the ability to withstand the

effects of short-circuit currents, defined as symmetrical short circuit current in the Technical Schedules, according to requirements of IEC 60076-5.

All metal parts of the shunt reactor with the exception of the individual core laminations, core bolts and associated individual side plates shall be maintained at the same fixed potential. The earthing structure shall be designed to carry, without damage, the maximum possible earth fault current for a duration of at least equal to the short circuit withstand period of the main windings.

The design and manufacture of the shunt reactors and auxiliary plant shall be such that the noise level is at a minimum and that the level of vibration does not adversely affect any clamping or produce excessive stress in any material. The shunt reactor manufacturer shall supply sufficient information to the civil works Bidder to ensure adequate design of the reactor mounting structure.

Where noise measurements are specified, measurements shall be in accordance with IEC 60076-10.

The shunt reactors shall be designed with particular attention to the suppression of harmonic currents, especially the third and fifth, so as to minimize interference with communications circuits.

The shunt reactors shall be designed to ensure that leakage flux does not cause overheating in any part of the reactor.

The reactors shall be capable of withstanding the effects of periodic switching in and out without suffering stresses that may damage the unit or associated equipment or affect the life of the unit.

All outdoor terminal boxes, marshalling box etc which are directly exposed to air shall have sunshades with capability to work as rain protection shield.

Shunt Reactors shall be equipped with HV bushing CTs for unit protection.

External earthing with proper copper jumpers shall be provided at all gasket joints in the shunt reactor such as radiator connection with the main tank. All copper jumpers shall be flexible bread conductor. Jumpers shall be tin platted.

16.3.2 **Magnetic Circuit**

The core shall be built up of high-grade, non-ageing, low-loss, high-permeability grain oriented steel sheets. Both sides of each steel sheet shall be insulated with a durable, hot oil and heat resistant baked enamel varnish or other chemical treatment.

The cores shall be clamped and braced to withstand, without damage or deformation, the forces caused by short circuit stresses, transportation, or handling, and to prevent the shifting of the core laminations. The bolts, nuts, and end plates of the assembly

and clamp structure shall be of a nonmagnetic type, and shall be effectively insulated and locked so that they ensure an even pressure on the whole core assembly and are not loosened by vibrations caused by transport and operation. The supporting framework of the cores shall be designed to avoid the presence of pockets which could prevent complete draining of the tank or cause the trapping of air when filling during service.

Suitable axial cooling ducts shall be provided to ensure free circulation of oil and efficient cooling of the core. The ducts shall be so dimensioned that the maximum temperature at any point remains with the admissible limits.

Particular care shall be given to the design and construction of the corner joints between columns and yokes to avoid concentration of mechanical and magnetic stresses whilst allowing an easy dismantling of the joint for maintenance at site.

Adequate metallic bridges shall be provided between the core lamination packets in order to keep all portions of the core assembly at the same potential.

Lifting eyes or lugs shall be provided at suitable points of the core assembly.

The core shall be earthed to the clamping structure at one point only through a removable link with a captive bolt and nut, accessibly placed beneath an inspection housing on the tank cover or tank wall.

The core shall be free from overfluxing liable to cause damage or to cause maloperation of the protection equipment when the shunt reactor is operating under the continuous overvoltage condition specified in the Technical Schedules.

16.3.3 **Windings**

The windings shall be of high conductivity electrolytic copper. Paper shall be used for conductor insulation.

The conductors shall be transposed at sufficient intervals to minimize eddy currents and equalize the current and temperature distribution along the winding. Coils shall be constructed to avoid abrasion of the insulation, (e.g. on transposed conductors), allowing for the expansion and contraction set up by the changes of temperature or the vibration encountered during normal operation.

Windings shall be so designed as to obtain an optimal value for series and shunt capacities in order to ensure a favourable distribution of the voltage for full impulse waves and chopped impulse waves.

Leads from winding to bushings shall be adequately supported to prevent damage from vibration and short-circuit forces.

Permanent current-carrying joints or splices shall be welded or braced, properly

formed, finished and insulated to avoid concentration of dielectric stresses.

The windings shall be subjected to a thorough shrinking and seasoning process. Compensation devices shall be provided for possible further shrinkage of the coils in service.

The coils, windings and leads shall be sufficiently braced and fastened to form rigid assemblies, preventing any relative movement due to transport, vibrations or other circumstances that may occur in service.

The windings shall be designed to reduce to a minimum the out-of-balance forces inherent in the shunt reactors.

The winding shall be capable of withstanding the forces to which it is subjected under all conditions, particularly the forces due to a short circuit between terminals or between any terminal and earth, with full voltage maintained on all other windings intended for connection to external sources of supply and allowing for any feed back through windings connected to rotating machines.

The assembled core and windings shall be dried in a vacuum to ensure proper moisture removal.

16.3.4 **Neutral Earthing**

The neutral point of shunt reactor shall be directly connected to earth.

16.3.5 **Tank**

The shunt reactor tank shall be of welded construction with bolted cover, fabricated from high tensile strength steel plate.

The tank shall be of adequate strength so that, when containing the core plus coil assembly and fully oil filled, any packing, lifting, rolling and handling shall not cause overstressing of any part of the tank or leakage. The main tank body, tap changing compartments, radiators and associated piping facilities shall be capable of withstanding full vacuum when empty of oil.

Each tank shall be provided with minimum of four jacking pads conveniently located to allow the raising or lowering of the completely mounted and oil filled shunt reactor. The load carrying capacity of each jacking pad shall not be less than 50% of the total weight of the shunt reactor. Lifting eyes or lugs for lifting the complete shunt reactor and tank cover and facilities for the pulling and pushing of the shunt reactor in any direction shall be provided for each unit. Tank stiffeners and mounting brackets shall be continuously welded to the tank.

The movement of the shunt reactor shall be achieved by a set of bi-directional wheels.

The change of the direction shall be made after lifting the shunt reactor with hydraulic jacks.

The shunt reactors, when erected, will be left standing on their wheels. The wheel blocking devices necessary to fix the position of the shunt reactor shall be supplied together with the shunt reactors, and shall be designed to withstand seismic forces acting upon the shunt reactors.

Wherever possible, the shunt reactor tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 20mm and, if necessary, shall be protected against mechanical damage.

The shape and arrangement of the tank cover and external stiffeners shall permit rainwater and desert sand to flow easily and completely to the ground.

All oil-tight joints shall be made with machined flanges and approved types of gasket.

The gaskets shall be tight under all conditions, especially against the hot oil (synthetic rubber or neoprene-bonded cork is not permitted). Means shall be provided to prevent over compression of the gaskets. The tanks shall be provided with bolted type manholes for easy inspection of bushings and windings.

The tank cover shall be fitted with thermometer pockets, for oil and winding temperature indicators, with a captive screw cap and be located in the position of maximum oil temperature at continuous maximum rating.

A pressure relief device of self re-setting type and sufficient size capable of functioning without electrical power, shall be provided for the rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment, but it shall be capable of maintaining the oil tightness of the shunt reactor under all conditions of normal service. The device shall operate at a static pressure of less than the hydraulic test pressure for shunt reactor tanks and shall be designed to prevent further oil flow from the shunt reactor during its operation.

The relief device shall be mounted on the main tank and if mounted on the cover it shall be fitted with a skirt projecting inside the tank to prevent an accumulation of gas within the device. Two sets of contacts shall be provided to initiate the alarm and trip relays.

Terminals shall be provided close to each corner at the base of the tank for earthing purposes and each shall be designed to meet system fault levels.

Each of the shunt reactors shall be provided with a tank access ladder made of galvanized mild steel with lockable hinged door and anti-climbing device securely fixed onto the tank cover and lower parts of the tank.

The following plates shall be fixed to the tank at an approximate height of 1.75 m above the ground level:-

A. A rating plate bearing the data specified in IEC standard.

Following additional information shall be provided in the rating plate:

a. Loss in kW
b. Magnetising current in %
c. HV winding resistance (ohm/ phase)
d. Reactance

B. A diagram plate.
C. A property plate of approved design and wording.
D. A title plate.
E. A valve location plate showing the location and function of all valves, drain and air release plugs and oil sampling devices.

16.3.6 **Valves**

Valves shall be of the fully sealing full-way type and shall be opened by turning counter-clockwise when facing the handwheel. They shall be suitable for operation between the minimum ambient and the maximum oil temperatures stated in the Schedules. All valves shall be lockable with appropriate sub-master series padlocks. Padlocks shall be provided for locking all valves in the “open” and “closed” positions. Valves other than filter and drain valves shall be provided with an indicator, readily visible from ground level, to show clearly the position of the valve. All valves shall have tags attached to it permanently clearly indicating its position (i.e close / open) in normal service condition of the shunt reactor.

All valve handwheels shall be fitted with nameplates which shall be chromium plated brass not less than 3 mm thick with the engraving filed with enamel. All valves shall be fitted with spoked handwheels, the spokes and rims of which shall be smooth and where necessary, for appearance, shall be chromium plated.

Each shunt reactor tank shall be fitted at least with the following:

- One 50 mm valve at the top and one 50 mm valve at the bottom of the tank, mounted diagonally opposite each other, for connection to oil circulating and oil filtering equipment. The lower valve shall also function as a drain valve, for which a suitable combine arrangement shall be made.

- Oil sampling devices at the top and bottom of the main tank

- All parts containing oil, and liable to trap air during filling, shall be fitted with a flanged type air release plug at their highest point.

- Valves shall be provided on both sides of the gas and oil actuated relays.

All valves opening to atmosphere shall be fitted with blanking plates.

16.3.7 **Conservator**

Shunt reactors shall be fitted with an oil conservator.

The conservator shall be made of welded steel. It shall be designed to withstand full vacuum. The conservator shall be of sufficient volume to enable expansion and contraction of oil within the highest and lowest oil levels in the conservator.

The conservator vessel shall be mounted at the highest point of the oil system and shall be connected to the highest point of the tank through a straight sloping pipe. Adequate isolating valves shall permit the removal of the main and tap-changer Buchholz relays while the conservator is still connected to the tank by a pipe bypassing the relays.

Each conservator compartment shall be equipped with filling valve, drain valve, lifting lugs, etc. The main tank conservator shall be fitted with a gauge glass or universal oil indicator other than magnetic oil level gauge. An oil level gauge complete with low-level alarm shall be fitted to each conservator. The indicated minimum oil level shall occur when the feed pipe to the main tank is covered with not less than 12 mm depth of oil. The oil levels at 15℃, 35℃ and 90℃ shall be marked on the gauge. The oil level indicator of the magnetic oil level gauge(s) shall be calibrated in such a way that its position at 90 degree level corresponds to approximately half level of oil.

The front cover of all gauges shall be made of glass. Size of text/indications shall be such that it can be visible from ground.

16.3.8 **Oil**

The shunt reactor oil shall comply with IEC 60296 and other relevant IEC standards. The oil shall be a highly refined mineral oil suitable for use as an insulating and cooling medium in shunt reactors. The oil shall be free from corrosive sulphur and PCB.

16.3.9 **Cooling Plant**

Shunt reactors shall be ONAN cooled.

All radiator valves shall be lockable with appropriate sub-master series padlocks. Padlocks shall be provided for locking all valves in the “open” and “closed” positions. Valves other than filter and drain valves shall be provided with an indicator, readily visible from ground level, to show clearly the position of the valve. All valves shall have

tags attached to it permanently clearly indicating its position (i.e close / open) in normal service condition of the shunt reactor.

16.3.10 **Terminations**

Termination bushings shall be resin impregnated paper type or oil impregnated paper type with a power factor test tapping and porcelain external insulator, in accordance with IEC 60137. All bushings and connecting leads shall have a minimum current rating of at least 120% the maximum line current in order to accommodate IEC 60354 loading. Routine power frequency test levels on bushings shall be at a test voltage at least 10% higher than the Induced/Applied values applied to the shunt reactor.

16.3.11 **Neutral Connections**

The neutral ends shall be brought out externally via separate bushings.

16.3.12 **Protection, Measuring and Indicating Devices**

The Shunt reactors shall be equipped with several protection, measuring and indicating devices supplied by the shunt reactor manufacturer:

Buchholz relay shall be fitted to shunt reactor main tank. It shall have:

- Alarm contacts which close when gas collects or at low oil level
- Tripping contacts which close following an oil surge, and gas collection in the 2nd stage.
- The normally open, electrically separate, alarm and tripping contacts shall not be exposed to oil.
- The buchholz device shall be inserted in the pile work and provided with suitable valves on both sides of the devices to facilitate easy service.
- By-pass with control valves shall be provided to enable oil to by-pass the buchholz device during oil filteration.
- Each relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay from ground level.

If fitted, the characteristics of any winding temperature indication devices shall be submitted for approval prior to the delivery of the shunt reactors and shall also be included in the operating and maintenance instructions.

- A dial type oil thermometer with two (alarm/trip) adjustable contacts shall be mounted in the control cubicle. It shall be of conventional construction with a sensing bulb positioned in a separate pocket arranged in the top oil capillary and connected with a dial.
- An oil thermometer, connected to a resistance (platinum 100 W at 0oC) inside a stainless steel tube placed in a pocket located in the oil, suitable for remote and

supervisory remote measuring.

All thermometer temperature sensing devices shall be with heating elements for the purpose of calibration at site.

All indicating instruments shall have hard glass font covers.

16.3.13 **Control Cubicles**

Each shunt reactor shall be fitted with a control cubicle of welded galvanized sheet steel housing, mounted on the shunt reactor tank, in a position easily accessible from the ground level. The cabinet shall contain protective equipment associated with the reactor cooling system, as well as the termination of all secondary circuits.

The internal arrangement of the cabinet shall keep the various circuits clearly separate from each other, permitting easy and safe independent maintenance and repair of each of them without disturbing the others.

16.4 SHUNT REACTOR INSPECTION AND TESTING

16.4.1 **General**

All tests shall be performed in accordance with IEC 60076 and other relevant IEC Standards.

16.4.2 **Factory Test**

Routine and Type tests shall be generally in accordance with the requirements of IEC standards appropriate to the voltage class of the shunt reactor under consideration. Additionally, some tests identified as ‘Special’ in IEC 60076 are included, which may in practice be effectively a Routine or Type Test, as appropriate.

16.4.3 **Routine Test**

The following routine tests shall be performed:

1. Measurement of winding resistances
2. Measurement of reactance
3. Measurement of losses.
4. Lightning Impulse (LI) test
5. Switching Impulse (SI)test

6. Induced-voltage test with partial discharge measurement
a) Long Duration AC (ACLD)

7. Separate source voltage test

8. Oil test including Dissolved Gas Analysis and function tests of auxiliary equipment, before and after Dielectric Test

9. Measurement of insulation of core.

10. Oil leakage test

16.4.4 **Type Test**

The following type tests shall be performed:

1. Temperature Rise Test

2. Dissolved Gas Analysis of Shunt Reactor Oil shall be carried out before and after the Temperature Rise Test.

3. Dielectric test (Lightning Impulse test, Switching Impulse test)

16.4.5 **Special Test**

The following 'special' category tests shall be performed and may be on each unit (equivalent to a routine test) or on one unit (equivalent to a type test) as indicated:

1. Dielectric tests; tests under Routine and Type Tests. The applicable special dielectric tests are:

• Chopped wave lightning impulse. This test is a requirement at all system voltages on line terminals and shall be at 110% of the full wave impulse level: Routine test

2. Measurement of zero-sequence impedance: Routine test

3. Determination of sound levels to IEC 60076-10: Type test

4. Measurement of the harmonics of the no-load current: Routine test

5. Measurement of the mutual impedance between phases.

6. Determination of capacitance, windings to earth and between windings: Routine test

7. Measurement of insulation resistance to earth and loss angle of insulation system capacitances: Routine test

8. Determination of magnetic characteristic: to be linear up to 125% of nominal voltage

9. Vibration test (Routine): 200 µm peak-to-peak maximum.

10. Measurement of Capacitance & dissipation factor (Tandelta) for winding and bushings.

11. Measurement of current at low voltage

12. SFRA (Sweep Frequency Response Analysis) test.

16.4.6 **Site Test**

The following tests, after installation on Site shall be performed:

1. Verification of correct and complete erection

2. Verification of the soundness of porcelain surfaces and sealing

3. Verification of correct connections to the earthing system

4. Checking of auxiliary and control wiring and cabling and operation of all electrical LV equipment

5. Voltage tests of all electrical LV circuits

6. Measurement of the physical, chemical, and electrical characteristics of the oil after filling

7. Resistance measurements of windings with records of oil & ambient temperatures

8. Insulation resistance tests on winding, bushings, core, etc.

9. SFRA (Sweep Frequency Response Analysis) test

10. Measurement of Capacitance & dissipation factor (Tandelta) for winding and bushings

16.4.7 **Tests on Shunt Reactor Components**

Tests during and after manufacture shall be carried out on the shunt reactor components in order to verify compliance with the Specifications, good workmanship

and their capability to perform the required duties when in service.

Unless otherwise specifically mentioned these tests shall be made in accordance with the Section 15, Volume 2 of 3 of the Bidding Document.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 17 (Not Applicable)

POWER LINE CARRIER, TELEPROTECTION AND COMMUNICATION EQUIPMENT

SECTION 17
(NOT APPLICABLE)

POWER LINE CARRIER, TELEPROTECTION AND COMMUNICATION EQUIPMENT

17.1 POWER LINE CARRIER EQUIPMENT

17.1.1 General

Power Line Carrier equipment shall be installed on the 400 kV transmission networks associated with the project. The carrier frequency range available is between 50 to 500 kHz.

Single line drawing the existing and planned arrangements of power line carrier system. All materials and equipment offered shall be brand new, from the manufacturer's normal and standard construction, designed and manufactured according the latest technological methods.

Existing power line carrier (PLC) and communication equipment which are of has been supplied by ABB of Switzerland. For the purpose of standardisation of operating performance and facilities offered equipment shall be compatible with the existing ones.

Equipment providing increased signalling capacity, based on digital techniques shall be offered satisfying the following requirements:

- the high frequency bandwidth requirements are no greater than the SSB type.
- the digital equipment will not affect analogue equipment in service on the same line.
- an applicable schedule of technical particulars and guarantees is prepared and included with the Bid.
- full details of in service installations are included.

Should equipment manufactured by a different supplier be proposed, Bidders are to verify that the equipment shall be fully compatible with existing system and equipment and provide evidence that the equipment has been successfully interfaced with the existing type and is in continuous commercial operation.

17.1.2 Carrier Frequency Allocation

The Contractor shall submit a comprehensive carrier frequency allocation plan which shall be subject to the approval of the Employer. Before approval however, the Contractor shall agree all carrier frequency plans and power output with the governing radio frequency licensing authority to ensure non-interference with Air Traffic Control, and Marine Navigation Beacons, etc.

17.1.3 Line Coupling

(a) General

The high voltage transmission system is a three phase 50Hz system solidly earthed with the following design parameter detailed elsewhere in this specification:

Rated Voltage (kV)	420
Nominal Voltage (kV)	400
Symmetrical Short Circuit Current, 1 sec (kA)	63
Lightning Impulse Withstand Voltage (kVp)	1425
Continuous Switchgear Rating (A)	5000

All current carrying equipment shall be capable of withstanding these conditions for a period of one second.

(b) Method of Coupling

Coupling of the carrier signals to the double circuit transmission lines shall be phase to phase by means of capacitor voltage transformers supplied under this contract.

The Contract shall include all line traps and mountings, coupling filters, conductor clamps, HF connections, matching transformers, HF cables and glands required to complete the HF installation at site.

(c) Line Traps

New line traps shall have at least the same continuous rating as the switchgear and shall be capable of withstanding the short circuit current for one second.

The preferred value of coil inductance is 1 millihenries although other values will be considered depending upon the Bidders frequency plan.

The line traps shall be broad band tuned by means of a tuning device, which shall preferably be arranged to permit interchange without removing the line trap. The ohmic resistance shall preferably be 600 ohms or greater.

The line trap shall have a protective device which utilises non-linear resistor type arrestors and the nominal discharge current shall be 10kA.

Bidders shall submit type test reports or be expected to demonstrate that their line traps satisfy the tests recommended in IEC publication 353 - Line Traps, with regard to temperature rise, short time current rating, protective discharge, and also the HF rejection bandwidth.

All line traps shall be provided with bird barriers and clearly visible rating plates which will include the following data:

i) Manufacturer's name
ii) Type
iii) Serial number
iv) Rated continuous current
v) Rated short time current with respect to time
vi) Rated coil inductance
vii) Total mass (kg)

whilst the tuning device shall be similarly marked detailing:

i) Manufacturers's name
ii) Type
iii) Serial number
iv) Frequency band(s) etc., in kilohertz
v) Rated protective level of the tuning device.

Line traps are to be mounted on capacitor voltage transformers, supplied under this Contract and Bidders shall detail the type of mounting and connecting plates available for the line conductor and busbar connections.

17.1.4 Capacitor Voltage Transformers

New capacitor voltage transformers (CVT) and lattice steel structures shall be provided suitable for mounting line traps on them.

The capacitor shall have a rated capacitance of not less than 6000pF at the working voltage, an impulse withstand voltage as specified and meet the insulation level and test voltage equivalents of IEC recommendation for each device (IEC Publication 358 - Coupling Capacitors and Capacitor dividers). Creepage distances will be 25mm/kV (based on maximum phase to earth voltage).

Full technical details of the capacitor voltage transformers shall be provided in the Schedules of Guarantees and Technical Particulars.

17.1.5 HF Coupling Units

The high frequency coupling units shall be assembled in a sheet steel box or similar and be suitable for mounting on the pedestal support for the capacitor voltage transformer, or coupling capacitor. The filters are to be suitable for outdoor use in a hot dusty/humid climate and are to have weatherproof door seals together with breather holes to avoid condensation. The units are to have an earthing switch which should preferably be interlocked with the box door/lid such that the latter cannot be opened unless the earth switch is closed to earth the device, and clear indication of

the ON/OFF position of this switch should be indicated. The terminal of the filter which shall be connected directly to the substation earth shall be clearly designated.
The coupling device shall meet in full the safety and protection requirements of the IEC recommendation for such devices (IEC publication 481 - Coupling devices for power line carrier systems).

The tuning range of the coupling unit(s) shall be suitable for the HF carrier frequency allocations being provided on this Contract. Full details of the Bidder's proposals shall be submitted for approval by the Employer and appropriate Authority. The device shall be fitted with a rating plate clearly defining, but not limited to, the following data:

i) Manufacturer's name
ii) Type
iii) Serial number
iv) Peak envelope power
v) Available bandwidth or working range

Bidders shall be expected to demonstrate that their equipment complies with the following tests:

(a) Drain coil - measurement of impedance at power frequency
- current carrying capacity at power frequency 1 amp RMS continuous and 50 amps RMS for 0.2 seconds.

(b) Power frequency voltage tests on the isolation transformer of 5 kV RMS for one minute between each coil and earth, and between each coil and screen.

(c) Composite loss at several frequencies within the working range of the filter.

(d) Return loss at several frequencies within the working range of the filter.

(e) Impulse voltage test on each phase to phase filter, in accordance with Section 6 of IEC Publication 60.

The coupling filters detailed above shall be mounted on the CVT or CC pedestals, unless a waterproof housing is provided in the base of the coupling capacitor or CVT, at a height such that the external HV (primary) terminal on the coupling filter shall be at a minimum height of 2440mm above ground level.

Full technical details of the HF coupling units shall be provided in the Schedule of Technical Particulars.

17.1.6 High Frequency Cable

Sufficient high frequency cable suitable to connect the coupling filters with the indoor PLC high frequency units shall be supplied. The cable shall preferably have a characteristic impedance of 75 ohms unbalanced or 150 ohms balanced depending

upon the impedance of the coupling filters and the indoor equipment. The cable shall be PVC covered, steel wire armoured with a further outer sheath of PVC.

Bidders shall clearly show the make up of the cable, together with details of the cable mechanical and electrical characteristics. Bidders shall also state the “short” time and continuous test voltages with which their cable complies.

17.1.7 Power Line Carrier High Frequency Unit

(a) General

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years when operating under the specified service conditions.

The design and performance requirements of the digital power line carrier equipment shall be equivalent or better than IEC 495.

The equipment to be provided shall be of the digital transmission signalling type, constructed on a modular basis with modules plugging into 19" (480 mm) shelves. The equipment shall be composed completely of solid state integrated circuits with a minimum of discrete components.

Equipment providing increased signalling capacity, based on digital techniques shall be offered satisfying the following requirements.

* The high frequency bandwidth requirements are no greater than the SSB type

* The digital equipment will not affect analogue equipment in service on the same line.

* Full details of in service installations are included.

(b) Information to be Submitted with the Bid

The Bidder shall submit the following with the Bid:

i) a technical description, which shall include full details of the design, operation, construction, performance and maintenance aspects of the equipment.

ii) detail performance of the equipment .

iii) a proposed frequency plan.

(c) Deleted

(d) Digital Carrier Terminal Equipment

The equipment design shall be based on complete flexibility over the RF frequency spectrum and also in the selection of services to be transmitted. RF allocation shall be achieved with programmable synthesisers and easily tuned RF filters. The allocation of the frequency band and of the services to be transmitted shall be carried out by means of a laptop computer with suitable software installed, it shall be interactive so that programming/reprogramming can be readily carried out at the factory and also at site.

The combined bit stream (containing speech/data etc.) shall be suitably digitally modulated (e.g. QAM, or PSK etc.) and converted to the selected nominal carrier frequency band for transmission over the power line.

The nominal impedance at the carrier frequency output shall be 75 ohms (un-balanced) or 150 ohms (balanced). Provision shall be made for terminating the output in an appropriate dummy load. The return loss within the nominal carrier frequency band in the transit direction shall be not less than 10dB.

Bidders shall provide calculations to justify operation of the PLC over the transmission line(s). This shall include allowance for line length/construction, coupling losses, adverse weather and fail margin - to obtain a suitable minimum BER (typically 10^{-6}). There shall not be any limitations in parallelling the digital PLC with other similar digital PLC terminals on the same transmission line, or with analogue PLC equipment. Bidders shall show clearly the methods of transmission used, and identify the necessary RF frequency spacing between PLC equipment, also any interface equipment needed. The switching off/on of a PLC terminal connected with any other PLC terminals in parallel, shall not cause any interference with other still working PLC.

(1) Telephone Channels

To implement speech channels into the data stream the speech shall be sampled. Together with the associated signalling and error coding a bit rate derived from a basic sampling rate of 8 kbit/s shall be typically provided. The interface of each speech channel shall cover the required application and provide for both 4-wire and 2-wire termination. The telephone channel shall be suitable for 4-wire working at transit stations as determined by the requirements of the telephone scheme. Circuits terminating at a station shall be suitable for connection to a two-wire telephone exchange, 2/4 wire switching shall therefore, be available as a standard facility.

Bidders shall state the method of telephone signalling.

Bidders shall state the relative 4-wire levels used for speech transmission and reception.

All speech and VT signal input and output circuits shall be balanced and have a nominal impedance of 600 ohms. The return loss within the effectively transmitted

frequency band shall be not less than 17 dB.

The interface of the speech channel shall include for inter PAX tie lines and “Long line” telephones. The speech channel interface shall manage the following types of interface:

- E&M
- MFC
- DTMF
- Decadic

(2) Data Transmission

Data channels shall be time multiplexed into the output bit stream. The interface for the data channels shall be RS 232 (V.24/V.28). The data channels shall be configured as any combination of synchronous or asynchronous channels.

Bidders shall state the capacity/number of data channels which can be equipped on a link.

Where an audio data channel interface is required to/from and FSK modem, a suitable 600 ohm FSK interface shall be provided. The centre frequency, shift frequencies, and modem levels which shall be managed shall be configurable.

(3) Receivers

To provide for level stability on the audio services, the receiver dynamic range shall be approximately 30 dB. Where PLC is required to signal over long transmission lines, proposals for maintaining adequate output capacity and suitable level stability on the audio services shall be included.

An alarm shall be raised in the event of the BER becoming degraded.

(e) Service Telephone

A service telephone shall be provided for the PLC terminal. The handset shall be located in the terminal cubicle. A means of telephone calling the equivalent telephone at the remote end of the link shall be included.

(f) Service Conditions

The noise generated within the terminals and the cross talk attenuation between speech and VF signalling channels shall comply with IEC recommendation 495.

The level of spurious emission shall be clearly stated in the schedules, together with the frequency response of the speech channel referred to 800Hz and the VFT signalling channels referred to 3.0 kHz.

The equipment shall operate to its stated performance with a variation in power supply

voltage of +20% and -15% of the nominal value.

(g) Voltage Withstand Requirements

The equipment shall be designed to withstand satisfactorily the insulation tests defined in Section 7 of IEC recommendation 495.

The equipment shall not be subjected to interference by the presence of electrical noise generated by disconnector switching operations. The bandwidth of such noise extends from 10 kHz to 1 MHz and can peak to 1200 volts at the coaxial termination. Limiting diodes of the avalanche type should be provided at the HF cubicle terminals in order to limit this voltage to 400 volts peak to peak.

(h) Test and Alarm Facilities

Clearly designated test points shall be provided on modules where adjustments are required or reference points are applicable. However, Bidders may offer alternative methods e.g. a hand held maintenance unit or laptop computer with appropriate software.

Supervisory facilities shall be provided for monitoring the HF output amplifier current, the BER and the cubicle supply voltage etc.

Alarm lamps or LEDs on the terminal shall as a minimum requirement show alarms for ‘receiver fail’, ‘transmitter fail’ and receive low BER. Bidders shall provide details of all alarms available on their equipment. An alarm lamp shall be provided on the cubicle, visible with the cubicle door closed.
In addition to the local annunciation on the PLC terminal, each alarm shall be provided with two sets of potential free contacts, for connection to external alarm monitoring systems.

17.2 TELEPROTECTION EQUIPMENT

The protection of the overhead lines shall be arranged as detailed in Section 5. Tele-protection equipment shall be provided for permissive tripping and direct tripping on the lines.

The permissive tripping signals are required to operate circuit breaker trip relays in conjunction with the distance protection and directional earth fault relays.

The direct tripping signals are required to operate remote circuit breaker tripping relays and hence shall have inherent security against maloperation due to noise present in the bearer channel.

The Bid shall include a technical description of the equipment, which shall include a description of the design, operation, construction, performance and maintenance aspects of the equipment.

17.2.1 Technical Requirements

The tele-protection equipment shall be of modular construction and will preferably be mounted in the power line carrier units and work satisfactorily under the service conditions specified.

Manufacturers shall clearly state the precautions taken in the design of their receiver to safeguard the output against the presence of noise in the channel, and show the difference between their range of equipments used for "direct" and "permissive" signalling.

In the case of the "direct" tripping equipment it shall not be possible to cause a trip output under any of the following conditions:

(a) Removal or reinsertion of any printed circuit module in either transmitter or receiver of a link, including the PLC equipment.

(b) Switching on/off of the power supply to the tele-protection equipment.

(c) Switching on/off of the power line carrier equipment at either end of the 132 kV line.

(d) Shorting of the output of the tele-protection transmitter or shorting of the input to the tele-protection receive.

(e) Operation of disconnectors in the high voltage switchgear.

(f) When the level of the input signal to the receiver is below the receiver fail alarm threshold.

17.2.2 Signalling Conditions

Bidders shall state the precautions taken in the design of the receiver to safeguard the output against the presence of noise in the communications media. Under no circumstances shall a direct trip signal output occur due to:

- an equipment fault
- removal/restoration of power to the teleprotection or communications equipment
- shorting of the teleprotection transmitter/receiver
- operation of primary switchgear plant
- removal of reinsertion of any PCB in a tele-protection or communications media terminal.

Teleprotection signal outputs shall be inhibited when the level of the input signal to the receiver is below the fail alarm threshold.

Bidders shall provide the following performance graphs:

Transmission time: SNR versus operate time.

Security: SNR versus probability of an unwanted command output.

Dependability: SNR versus probability of failure of an output command.

Bit error rate/performance details

FSK modems shall be programmable with respect to both signalling speed and centre frequency. Bidders shall state the VF allocation required by the teleprotection equipment.

Equipment operating on a frequency shift principle, shall continuously transmit a low level (guard) signal to monitor the communications channel and as much of the terminal equipment as possible. The trip frequency shall be transmitted at an increased level output.

Similarly, equipment which transmit coded signal messages for tripping/signalling, shall also transmit guard codes.

17.2.3 Signal Transmission Times

The transmission times required from receipt of an input to the provision of a command output at the remote location, shall be less than

- 20 milliseconds for permissive tripping
- 40 milliseconds for direct tripping

Equipment capable of transmitting more than a single teleprotection signal is only acceptable provided the specified transmission times are met under all circumstances, including when more than one/all signal inputs are initiated simultaneously or part way through a code transmission.

Equipment used for direct tripping shall have the facility to hold on the output signal, so as to be suitable for applications with circuit breaker automatic reclose schemes, to prevent the remote circuit breaker reclosing until the faulted plant is disconnected from the HV system as detailed in a separate section of this Specification.
Direct tripping and permissive signals shall have a trip extension facility. The extension time shall be selectable, typically 200ms.

Bidders shall advise the minimum input pulse length (and the corresponding output), that is required to provide a guaranteed output. Also any limitation on the maximum output pulse length.

17.2.4 Interface

Data and control interfaces shall comply with CCITT RS232 and V24/V28 recommendations.

For digital communications media the interfaces shall comply with X21.

The transmitter signal command shall be initiated by means of the protection equipment switching both poles of the station dc supply to the teleprotection input.

The receiver command output shall be a semiconductor or relay arrangement providing two sets of “contacts”, with the “contacts” normally open (“contacts” shall be closed for a command output). These command output contacts shall be used for switching both poles of the station d.c. supply to the protection equipment.

The receiver shall also provide two sets of potential free command output auxiliary contacts, for connection to external alarm monitoring systems.

The rating of the above “contacts” shall be to the plant requirements.

The insulation requirements of the protection interface shall be 2 kV rms for one minute (IEC recommendation 255).

Individual counters shall be provided to show the number of teleprotection input and ouput commands which have been executed.

17.2.5 Service Conditions

The equipment shall operate to its stated performance with a variation in power supply voltage of +20% and -15% of the nominal value.

The equipment shall incorporate measures to ensure that signals are received and executed in the presence of noise on the communications channel. In the case of coded messages for example, transmission of a single “trip” code is a non preferred arrangement.

17.2.6 Voltage Withstand Requirements

Voice frequency, signalling and alarm circuits, when free from earth, shall be capable of withstanding without damage a voltage of 500 V d.c. applied for one minute between the terminals of the circuit connected together and earth.

The equipment shall not be subject to interference by the presence of electrical noise generated by disconnector switching operations. The bandwidth of such noise extends from 10 kHz to 1 MHz.

17.2.7 Test and Alarm Facilities

Clearly designated test points shall be provided on modules where adjustments are required or reference points are applicable. Supervisory facilities shall be provided for monitoring the teleprotection input and output at the interface to the communications media.

The alarm output shall be maintained for a minimum period of 100ms, and the operational output shall not be possible until the alarm output condition is removed.

A separate low level (or BER) shall be given, but not prevent operation, when the input signal level drops by typically 6dB from normal. Bidders shall detail the alarm facilities which are available from their equipment and state the level or BER at which the receiver will cease to function.

Alarm lamps or LEDs shall be provided on the equipment, together with two sets of potential free contacts, for connection to external alarm monitoring systems. A cubicle alarm lamp shall also be provided, visible with the cubicle door closed.

17.2.8 Housing

Terminal equipment shall be constructed on a modular basis, accommodated in a 19" or ETSI standard rack configuration, mounted in a cubicle. Equipment required to operate over PLC shall be mounted in the PLC equipment rack.

17.3 OPERATIONAL TELEPHONE SYSTEM

A new PAX operational telephone system and equipment (suitable for at least 50 percent spare capacity of the required trunk interfaces and 30 subscriber interfaces) shall be provided and installed at Rampura substation and shall interconnect with the existing network. Bidders shall be deemed to have investigated the existing system.

The trunk numbering plan shall be compatible with the present scheme in service in Bangladesh.

The telephone signalling (dialling) system shall be compatible with the present system.

An alarm system shall be provided to indicate traffic failure including blown fuses, loss of power supplies etc. In addition, contacts shall be provided to facilitate extension of the alarms to the telecontrol equipment.

17.4 COMMUNICATIONS DC POWER SUPPLY EQUIPMENT

17.4.1 General

(a) Basis of Design

The equipment shall comply with IEC 176 and 478.

The charger shall be of either the thyristor controlled type or of the SMPS type. The battery shall be nickel cadmium type - as detailed in a separate section of this Specification.

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years, when operating under the specified service conditions.

(b) Operating Principle

The output of the charger shall, during normal operation, continuously supply the power requirements of the load whilst simultaneously maintaining the battery charge in the float charge mode. In the event of an interruption in the a.c. mains supply to the charger, the battery shall supply the load requirements for not less than the specified standby time - whilst maintaining the output voltage within permissible limits.

Upon restoration of the a.c. mains supply, the rectifier shall automatically resume supply of the load requirements whilst simultaneously recharging the battery at the float voltage.

17.2.2 Configuration

The power supply installation shall comprise two batteries and two charging sources. each charger shall be able to float charge both batteries as well as supplying the total load.

The total battery capacity shall be able to supply the total load (comprising the delivered load together with 20% spare for future use) for at least 10 hours in the event of failure of the a.c. mains supply.

The d.c. power supply equipment is required to limit the output voltage to the load within plus 15% and minus 15% of the nominal value, provided these values do not exceed the voltage guarantee of the load equipment. The power supply output positive shall be earthed.

17.4.3 Charger

(a) General

The charger shall operate according to the constant voltage current limiting principle and shall incorporate a soft start feature to gradually accept load on initial energising.

The charger shall restart automatically upon restoration of the a.c. mains supply following a mains supply interruption, and recharge the battery at the float voltage. Internal cooling shall be by natural ventilation. Forced cooling is not acceptable.

The charger shall be suitable for operation in parallel with one or more chargers, and shall include a current sharing facility.

The charger shall be of sufficient output capacity for the application, parallel operation of chargers (where required) is for the purpose of redundancy and not to satisfy the output current requirements.

(b) Charger Output

The output characteristic shall provide an output voltage regulation of ±1%, over the specified a.c. mains voltage and frequency range and for load changes 0-100%. The output voltage regulator shall be adjustable within limits approved by the Engineer and shall be so designed that special tools are not required for such adjustment. Compensation for battery temperature shall be provided.

The charger shall have protection against overloads or short circuits and shall limit the output current. Recovery to a constant voltage characteristic shall occur automatically at the end of the overcurrent/short circuit.

(c) Boost Charging

Manual boost charging shall be provided. A boost timer shall be included to prevent overcharging.

Operation of boost charging shall disconnect the charger and battery from the load. It shall not be possible for both chargers to be selected to boost charging at the same time, or for the load to become disconnected from both batteries and chargers simultaneously.

If the a.c. mains supply fails during boost conditions the two batteries shall be automatically connected in parallel by “no volt” contactors to the load.

It shall not be possible to connect a “boosted” battery to the load until its terminal voltage has fallen below the load equipment upper voltage limit.

(d) Noise and Interference

To avoid unacceptable levels of electrical noise in the load equipment smoothing of the d.c. output is required. This shall achieve a psophometric noise level at the output,

for loads between 0 and 100%, not exceeding the equivalent of 2 mV at a frequency of 800 Hz after weighting as specified by ITU-T (CCITT).

The relative harmonic content of the input current shall comply with the European Directive for EMC, the EN 60555-2 standard. In the case of SMPS chargers active power factor correction (i.e. boost for step up converter) shall be provided to control the power factor.
The production of radio frequency interference voltages shall not exceed the values of suppression grade “N”, as defined in EN 55017/55015 - for thyristor controlled type chargers, and suppression grade “B” as defined in EN 55022 for SMPS type chargers.

The performance of the d.c. power supply equipment unit shall not be affected, or in any way degraded, by the use of the following when the severity of the electromagnetic radiation environment corresponds to Class 3, in accordance with IEC 801-3:

- private mobile radio operating in designated or planned radio frequency bands
- current cellular radio equipment
- future cellular equipment
- mobile data equipment.

It is the Contractor’s responsibility to determine the radio frequency bands applicable in the locality.

(e) Efficiency/Rating

The charger efficiency shall not be less than 85%.

All chargers supplied shall preferably have the same rating, or be in fixed multiples, to limit the number of different charger ratings.

(f) Instruments, Controls and Alarms

The charger shall be equipped with the following

- a.c. mains input circuit breaker
- d.c. output circuit breaker
- charger output current meter
- charger output voltage meter
- alarms for charge fail, d.c. volts high etc.

Each alarm shall be provided with local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

17.4.4 Battery

(a) Type

Nickel cadmium cells shall be of the pocket plate type in accordance with IEC 623.

Cell containers shall be of the moulded plastic type, non flame propagating and mechanically shock resistant. They shall provide for the electrolyte level to be viewed through the container material.

Cells shall be permanently marked with the following information:

- manufacturer's reference number and code
- year and month of manufacture
- voltage and nominal capacity at the 5 hour rate
- cell number.

(b) Mounting

The batteries shall be mounted on metal stands, or racks, in a manner such that all the plates of each cell are visible for inspection, test and maintenance purposes. Stands or racks shall have a maximum of two tiers. In all cases adequate space must be left between the tiers for maintenance purposes and to permit the topping up of electrolyte. Stands or racks shall have a protective finish of not less than two coats of electrolyte resisting enamel or gloss paint. Alternatively, an epoxy resin sintered finish may be used.

At locations where the battery is not housed in a separate battery room the battery stand/rack shall be fitted with cladding. The cladding shall permit the free flow of air to the battery, and shall be removable for maintenance purposes.

Cell containers shall be accurately set up in alignment on the stand or rack with lead and/or rubber discs under the feet moulded on each container. Cell lids shall be so positioned that at least one topping up aperture is on the access gangway side of the cell and not obstructed by any inter-cell connecting arrangements.

(c) Battery Main Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated at five times the charger float output rated current. A cartridge fuse shall be provided in the charger input lead to the negative pole of the battery and rated at twice the charger float output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. These fuse links shall comply with BS 88.

Class DC 40 or equivalent and shall be mounted in fuse carriers with an insulated barrier between the poles.

The cable or busbar to the battery shall be firmly supported at a point near the cell

terminal pillar. Where two cables are used they shall be terminated one to either side of the terminal pillar. These cables shall be arranged as to allow some flexibility and to avoid any forces being applied to the cell terminal pillar.

(d) Connections

The positive pole of each battery shall be connected to station earth via a single bolted link at the distribution cubicle. Low resistance intercell connectors shall be used. Connections between tiers of cells and between end cells and fuses shall be made with insulated copper rod which shall be of equivalent cross-section to the distribution busbars.

Connections from the battery fuses to the chargers and distribution cubicles shall be made with insulated cable of equivalent cross-section to the distribution busbars. The positive and negative terminals of each cell shall be clearly indicated. The positive and negative terminals of the complete battery shall be indicated by red and black marking respectively.

(e) Capacity

The battery capacities shall be 250 ampere hours at the 5 hour rate.

17.4.5 D.C. Distribution and Instrumentation

(a) General

The distribution section shall be designed for incoming and outgoing d.c. supplies as follows:

- two independent supplies (including one for future use) incoming from the batteries and associated chargers. The battery negatives shall be connected to the distributed busbar through a single pole switch. The 48V battery positive shall be directly connected to the positive busbar.

- Each load equipment shall be connected to a distribution outlet. The use of teed supplies to more than one load equipment will not be permitted.

- Double pole miniature or moulded case circuit breakers to IEC 157 shall be supplied, fitted with auxiliary contacts which operate when the circuit breaker trips.

The MCBs shall be rated to meet the load requirements and shall be labelled with the destination of the load. Outgoing connections shall be brought to terminals, mounted in the cubicle, provided with strip connectors and cable lugs. The number of outlets shall cater for the quantity of load equipment items plus 50%, with a minimum of 10 outlets being provided, Space shall also be available for the installation of 10 extra outlets for future use.

(b) Instruments and Alarms

Instrumentation shall comprise

- battery ammeter (charge and discharge)
- battery voltage
- load current ammeter
- busbar voltage

An alarm indication shall be provided if the busbar voltage falls outside set limits.

The MCB auxiliary contacts and the high/low voltage alarm shall each provide local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

17.4.6 Housing

The above covers the mounting/housing for batteries.

A modular construction is preferred for the battery charger and d.c. distribution/instrumentation, with each unit comprising a single 19" or ETSI standard rack configuration, all mounted in a single cubicle.

The modular construction shall provide:

- simple plug in units for easy assembly and servicing
- individual battery charger unit removal in safety, without loss of output power to the load.
- expansion of capacity at a later date

In the case of Contractors who do not offer a modular construction, separate cubicles are required for each charger and the d.c. distribution/instrumentation.

POWER GRID BANGLADESH PLC

BIDDING DOCUMENT

FOR

Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

[Contract No.: POWERGRID/ADB/PTSIREP/230KV Monohardi & Madhabpur SS/PACKAGE-2]

SECTION 18

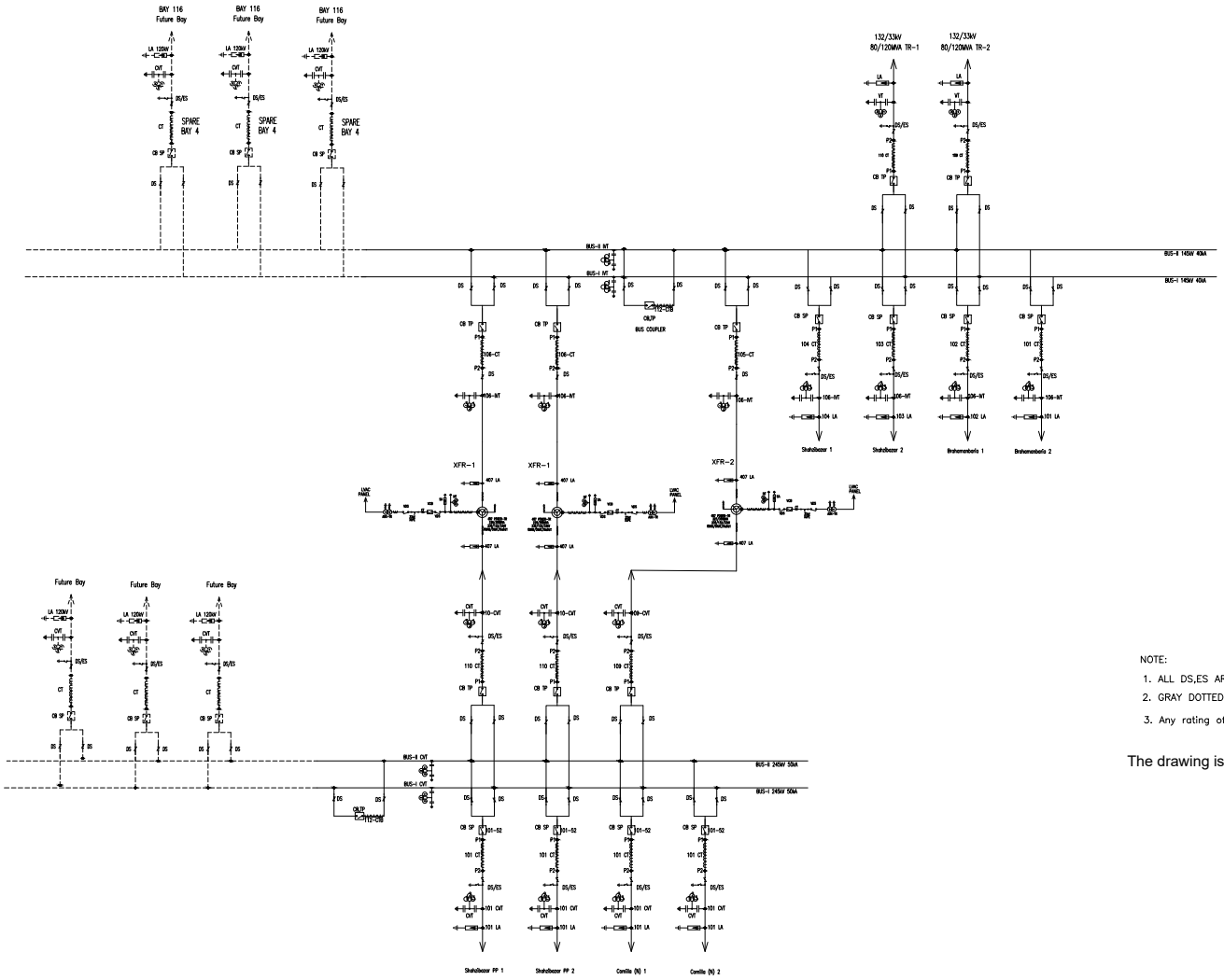
DRAWINGS

Section 18
Drawings

The drawings provided in this section are solely for the purpose of bid information and bid preparation. They present the typical details of the project facilities and plant requirements for the following.

List of Bid Drawings

Drawing No.	Drawing Title
PG/ADB/SLD.1	Madhabpur & Monohardi 230 & 132KV Single Line Diagram
PG/ADB/SLD.2	Bajitpur 132KV Single Line Diagram
PG/ADB/SLD.3	33 kV Single Line Diagram
PG/ADB/SLD.4	Tertiary Single Line Diagram
PG/ADB/LAY_all	Overall Layout
PG/ADB/ LP_230kV	230kV Line & Bus Protection
PG/ADB/230kV_BC	230kV Bus Coupler Protection
PG/ADB/Trans_230	230KV Tr Protection
PG/ADB/Trans_132	132KV Tr Protection
PG/ADB/ LP_132kV	132kV Line & Bus Protection
PG/ADB/132kV_BC	132kV Bus Coupler Protection
PG/ADB/SAS	Substation Automation System Architecture
PG/ADB/DC_110V	110V DC distribution scheme
PG/ADB/DC_48V	48V DC distribution scheme
PG/ADB/AC	LV AC distribution scheme
PG/ADB/OPT_Madhabpur	Madhabpur Optical Communication Scheme
PG/ADB/OPT_Monohardi	Maonohardi Optical Communication Scheme
PG/ADB/MCRP-1	Main Control Room Ground Floor plan
PG/ADB/MCRP-2	Main Control Room First Floor Plan
PG/ADB/MCRE	Main Control Room Elevation
PG/ADB/SPR_132	SPR with battery room for 132KV
PG/ADB//GH	Guard house
PG/ADB/SSL	Switchyard Surface Level
PG/ADB/CAR	Car Port with Solar
PG/ADB/Fence	Fence
PG/ADB/BW	Boundary Wall
PG/ADB/GATE	Gate
PG/ADB/AR	Approach Road
PG/ADB/TRS	Typical Road Sections
PG/ADB/SEP	Sentry Post
PG/ADB/ST	Septic Tank
PG/ADB/SW	Soak Well
PG/ADB/SLP	Slope Protection
PG/ADB/WW	Walk Way
PG/ADB/AB	Ansar Barrack
PG/ADB/SR	Stair Railing
PG/ADB/PL	Property Line Marking
PG/ADB/OSY	Open Storeyard
PG/ADB/CAM	IP Camera
PG/ADB/PFI	PFI Plant



NOTE:

1. ALL DS,ES ARE MOTOR OPERATED
2. GRAY DOTTED LINES INDICATE FUTURE BAYS
3. Any rating of Equipment please follow Schedule A

The drawing is Prelimilinary & is for Bidding Purpose Only

REV.	DATE	DESCRIPTION	BY	MEC.	ELE.	CIV.	C&I	SES	APPD.

PROJECT: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

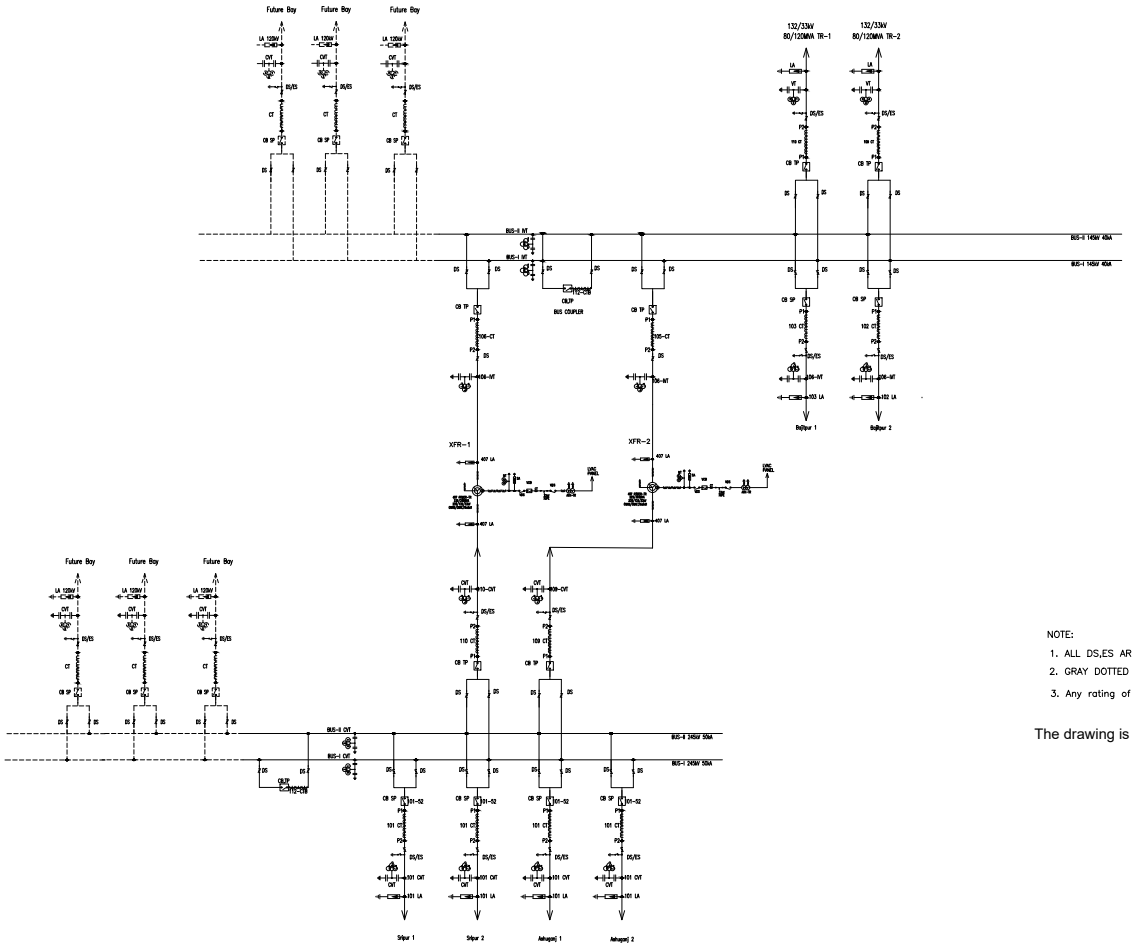
OWNER: POWER GRID BANGLADESH PLC

	DATE	NAME	SIGN.
DRAWN			

TITLE: Madhabpur 230kV/132KV OVERALL SLD

DRG. NO.: PG/ADB/SLD.1

SCALE: NTS SHEET: 1 OF 1



NOTE:

1. ALL DS,ES ARE MOTOR OPERATED
2. GRAY DOTTED LINES INDICATE FUTURE BAYS
3. Any rating of Equipment please follow Schedule A

The drawing is Prelimilinary & is for Bidding Purpose Only

REV.	DATE	DESCRIPTION	BY	MEC.	ELE.	CIV.	C&I	SES	APPD.

PROJECT:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajipur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
OWNER:	POWER GRID BANGLADESH PLC

	DATE	NAME	SIGN.
DRAWN			

TITLE: MONOHARDI 230kV/132KV OVERALL SLD

DRG. NO.: PG/ADB/SLD.1

SCALE: NTS SHEET: 1 OF 2

A1 (594mm x 841mm)

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POWER GRID COMPANY OF BANGLADESH LTD.
APPROVED With Comments given
This approval is general only and does not relieve the manufacturer/contractor/supplier from compliance with specification and standards for design, Workmanship and performance as stipulated in the contract.
Vide Letter No. 20.617; dated: 16/08/20

(Shafi Hasan Jamil)
Sub-Divisional Engineer
Design & Quality Control
PGCB Ltd.

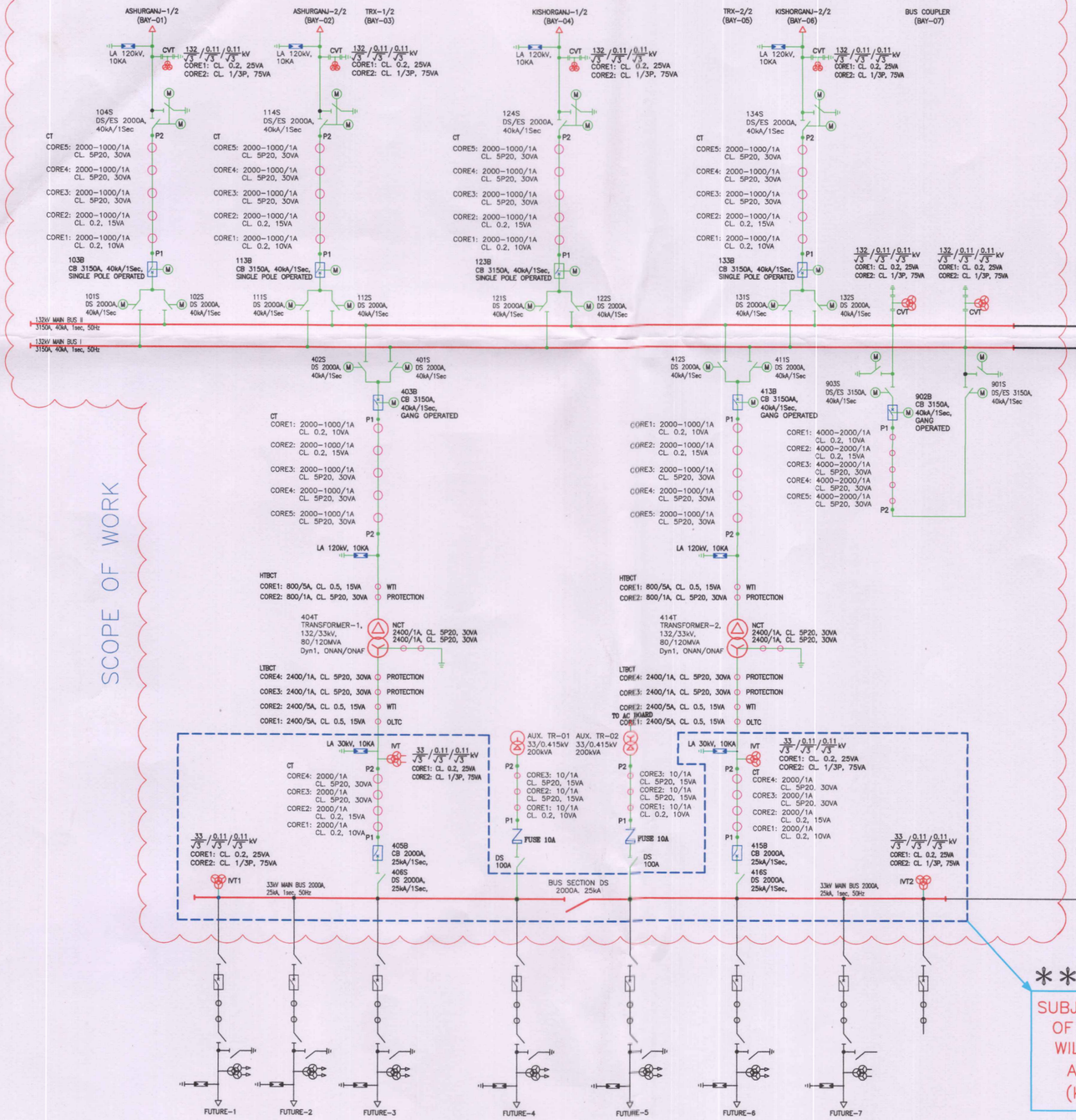
(Khaled Iftekhar)
Executive Engineer
Design & Q C (Substation)
PGCB Ltd
ID No. 00329

(Syed Abadullah Haider Alil)
ID NO: 00227
Superintending Engineer
Substation Design & Quality Control
PGCB Ltd.

16 AUG 2020

Sepcon Consortium of Sepcon Power Ltd. • M/S • Dhaka-1208 • PKG-2.1

SCOPE OF WORK



**

SUBJECT TO VARIATION OF BID DOCUMENT. WILL BE FINALIZED AFTER DONOR'S (KfW) COMMENT

LEGEND WITH BOQ: (132kV AIS SYSTEM)

EQUIP.	SYMBOL	DESCRIPTION	UNIT	QUANTITY
POWER TRANSFORMER		132/33kV, 80/120MVA Dyn1, ONAN/ONAF	SETS	02
CIRCUIT BREAKER (LINE BAY)		CB 3150A, 40kA/1Sec SINGLE POLE OPERATED	SETS	04
CIRCUIT BREAKER (TR. & BUS COUPLER BAY)		CB 3150A, 40kA/1Sec GANG OPERATED	SETS	03
CURRENT TRANSFORMER (CT) - 5 CORE (LINE & TR. BAY)		CORE1: 2000-1000/1A, CL. 0.2, 10VA CORE2: 2000-1000/1A, CL. 0.2, 15VA CORE3: 2000-1000/1A, CL. 5P20, 30VA CORE4: 2000-1000/1A, CL. 5P20, 30VA CORE5: 2000-1000/1A, CL. 5P20, 30VA	SETS	18
CURRENT TRANSFORMER (CT) - 5 CORE (BUS COUPLER BAY)		CORE1: 4000-2000/1A, CL. 0.2, 10VA CORE2: 4000-2000/1A, CL. 0.2, 15VA CORE3: 4000-2000/1A, CL. 5P20, 30VA CORE4: 4000-2000/1A, CL. 5P20, 30VA CORE5: 4000-2000/1A, CL. 5P20, 30VA	SETS	03
CAPACITIVE VOLTAGE TRANSFORMER (CVT)-2CORE (LINE BAY & BUS)		132kV/√3 / 0.11kV/√3 / 0.11kV/√3 CORE1: CL. 0.2, 25VA CORE2: CL. 1/3P, 75VA	SETS	18
DISCONNECTOR WITH EARTH SWITCH (LINE BAY)		DS/ES, 2000A, 40kA/1Sec	SETS	04
DISCONNECTOR WITH EARTH SWITCH (BUS COUPLER BAY)		DS/ES, 3150A, 40kA/1Sec	SETS	02
DISCONNECTOR WITHOUT EARTH SWITCH (LINE & TR. BAY)		DS, 2000A, 40kA/1Sec	SETS	12
SURGE ARRESTER (AIS. TYPE). (LINE & TR. BAY)		120kV, 10kA	SETS	18
CONDUCTOR- TACSR 800/55		CURRENT CARRYING CAPACITY 2055.7A	LOT	01

LEGEND WITH BOQ: (33kV AIS SYSTEM)

EQUIP.	SYMBOLE	DESCRIPTION	UNIT	QUANTITY
VACUUM CIRCUIT BREAKER		** 2000A, 25kA/1Sec.	SETS	02
CURRENT TRANSFORMER (CT) - 4 CORE		** CORE1: 2000/1A, CL. 0.2, 10VA CORE2: 2000/1A, CL. 0.2, 15VA CORE3: 2000/1A, CL. 5P20, 30VA CORE4: 2000/1A, CL. 5P20, 30VA	SETS	06
CURRENT TRANSFORMER (CT) - 3 CORE		CORE1: 10/1A, CL. 0.2, 10VA CORE2: 10/1A, CL. 5P20, 15VA CORE3: 10/1A, CL. 5P20, 15VA	SETS	06
DISCONNECTOR SWITCH		** 2000A, 25kA/1Sec.	SETS	02
BUS SECTION DISCONNECTOR SWITCH		2000A, 25kA/1Sec.	SET	01
DISCONNECTOR SWITCH WITH FUSE		DS (100A, 25kA/1Sec) FUSE (10A)	SETS	02
LIGHTNING ARRESTER		30kV, 10kA	SETS	06
AUXILIARY TRANSFORMER		200kVA, 33/0.415kV, Dyn11	SETS	02
INDUCTIVE VOLTAGE TRANSFORMER (IVT)-2CORE		33kV/√3 / 0.11kV/√3 / 0.11kV/√3 CORE1: CL. 0.2, 25VA CORE3: CL. 1/3P, 75VA	SETS	12
CONDUCTOR- TACSR 800/55		CURRENT CARRYING CAPACITY 2055.7A	LOT	01

System Parameters Table

Description	Units	Provided	
Nominal system voltage between phases	kV	132	33
System frequency	Hz	50	
Rated voltage between phases	kV	145	36
Rated lightning impulse withstand voltage	kV	650	170
Rated power frequency withstand voltage	kV, 1 min	275	70
Rated symmetrical short-circuit current	kA, 1 sec	40	25

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: Bajitpur 132/33 kV extension Single Line Diagram

Drawing no: PG/ADB/SLD.2

REV.	DATE	DESCRIPTION	DRAWING	DESIGNED	CHECKED	APPROVED
01	05.08.2020	FOR APPROVAL				
00	21.06.2020	FOR APPROVAL	S. I	N. M.	N. M.	R. A.

CONTRACT DOCUMENT FOR:
Design, Supply, Installation, Testing & Commissioning of 132/33kV Substations, on Turnkey Basis Under The Energy Efficiency in Grid-based Power Supply Project (Package 2.1).

Contract No.: PGCB/KfW/BMZ.2014.67.976/2018/Package-2.1

EMPLOYER : POWER GRID COMPANY OF BANGLADESH LIMITED (PGCB)

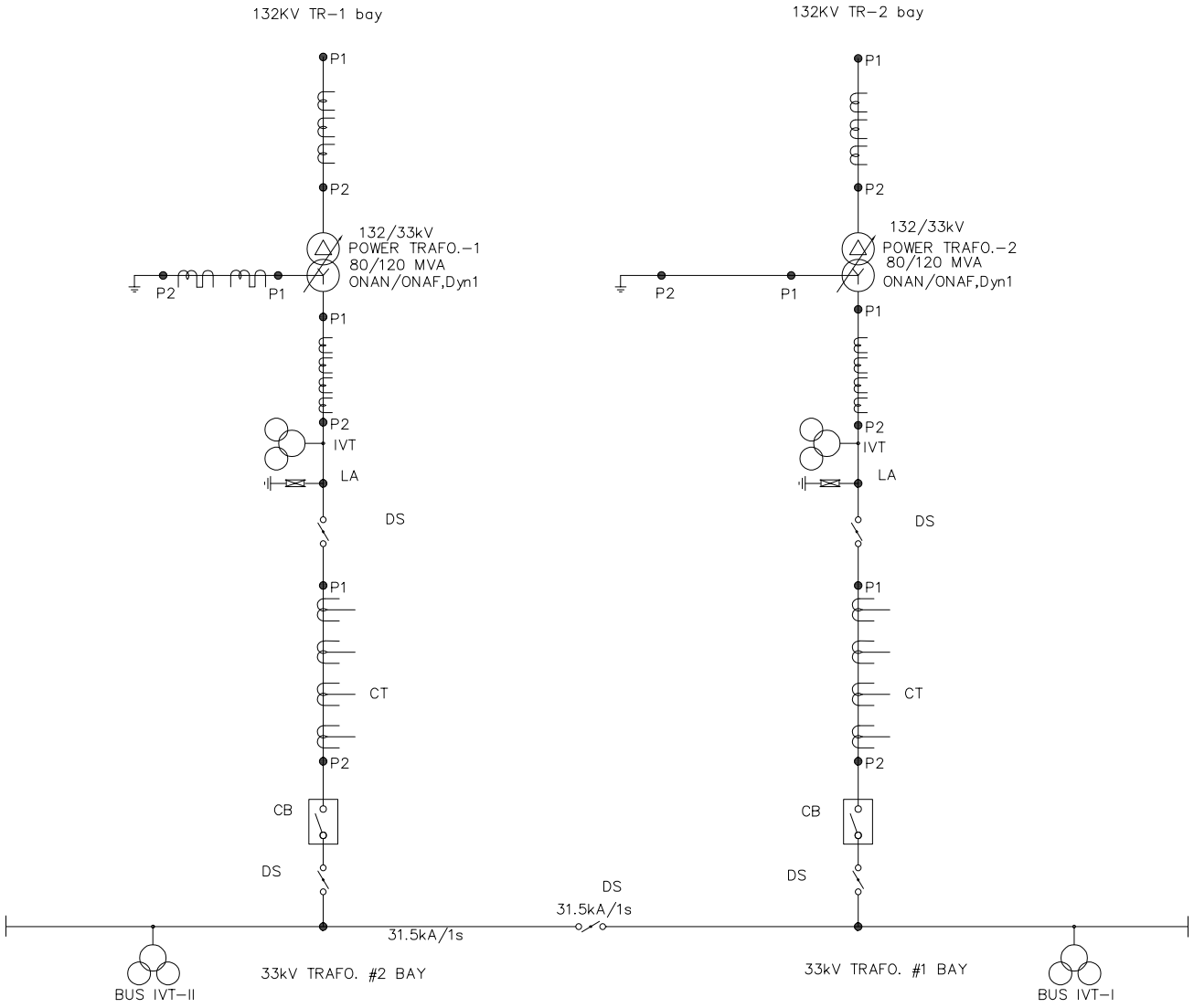
SUBSTATION NAME : BAZITPUR 132/33kV NEW AIS SUBSTATION.

CONTRACTOR : sepcoIII - Energypac Consortium

SCALE	NONE
DRAWN	S. I
CHECKED	N. M.
APPROVED	N. M.
DATE	21.06.2020

TITLE : BAZITPUR 132/33kV, 2x80/120MVA NEW AIS SUB-STATION. (SINGLE LINE DIAGRAM)

DRAWING NO. : 3320/PGCB/KfW/BMZ/2.1/BAZITPUR/SLD/E01 REV : 1



NOTE:

1. ALL DS,ES ARE MOTOR OPERATED
2. GRAY DOTTED LINES INDICATE FUTURE BAYS
3. Any rating of Equipment please follow Schedule A

Tender Purpose Only

REV.	DATE	DESCRIPTION	BY	MECH.	ELEC.	CIVIL	QM	SEC	APPR.

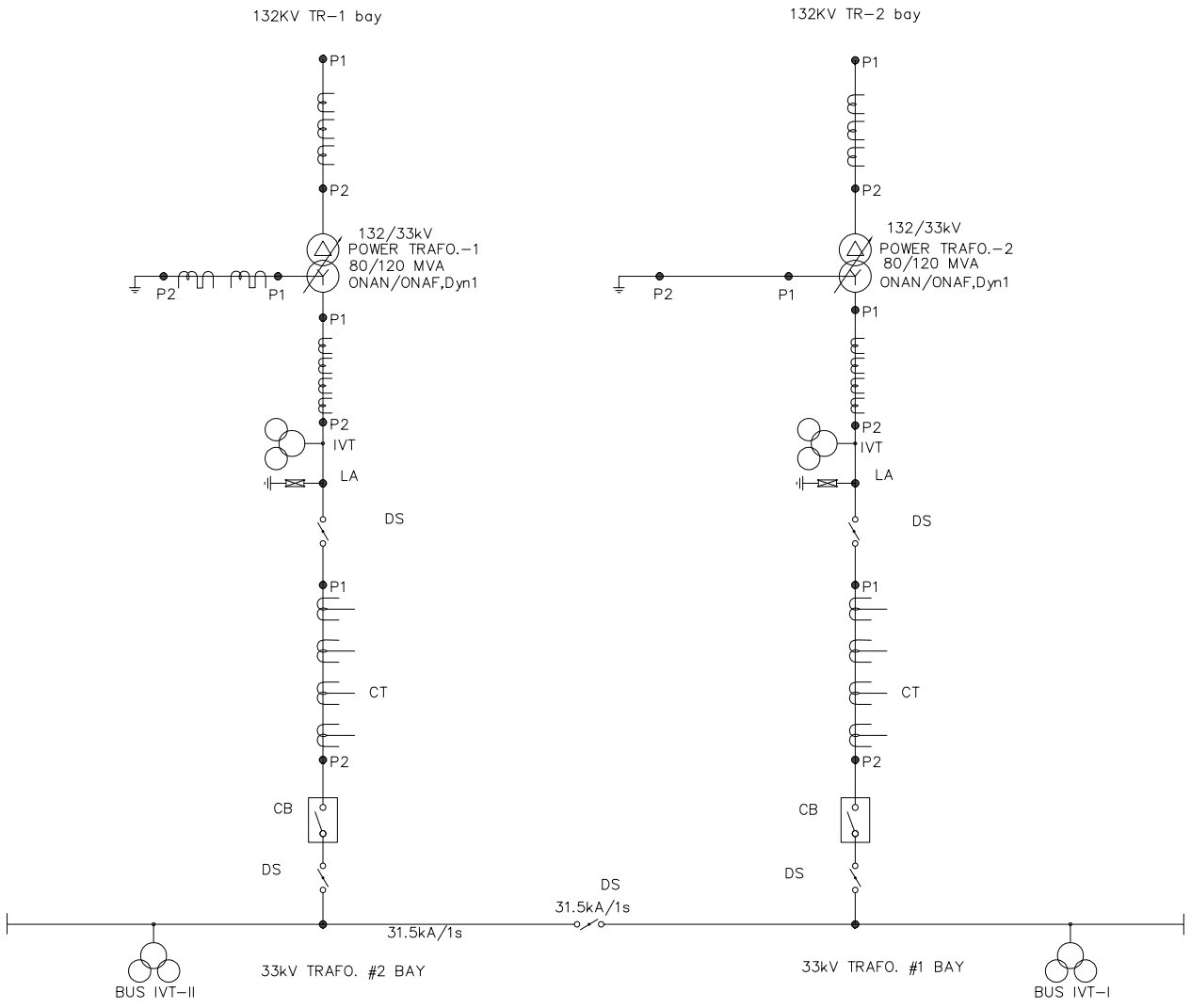
PROJECT: Design, Supply, Installation, Testing & Commissioning of 33kV Lines of Rp Substation at Madhabpur and Mirsharai including two nos. 132kV bay extension at Bagbari 132/33kV grid substation and associated 33kV and 132kV Transmission Lines on turnkey basis (Package-2)

OWNER: POWER GRID BANGLADESH PLC

	DATE	NAME	SIGN.	STUD
DRAWN				Madhabpur 33kV OVERALL SLD

DRG. NO.: PGA08/SLD.3

SCALE: NTS SHEET: 1 OF 2



NOTE:

1. ALL DS,ES ARE MOTOR OPERATED
2. GRAY DOTTED LINES INDICATE FUTURE BAYS
3. Any rating of Equipment please follow Schedule A

Tender Purpose only

REV.	DATE	DESCRIPTION	BY	REC.	CLK.	CHK.	CHK.	REV.	APPR.

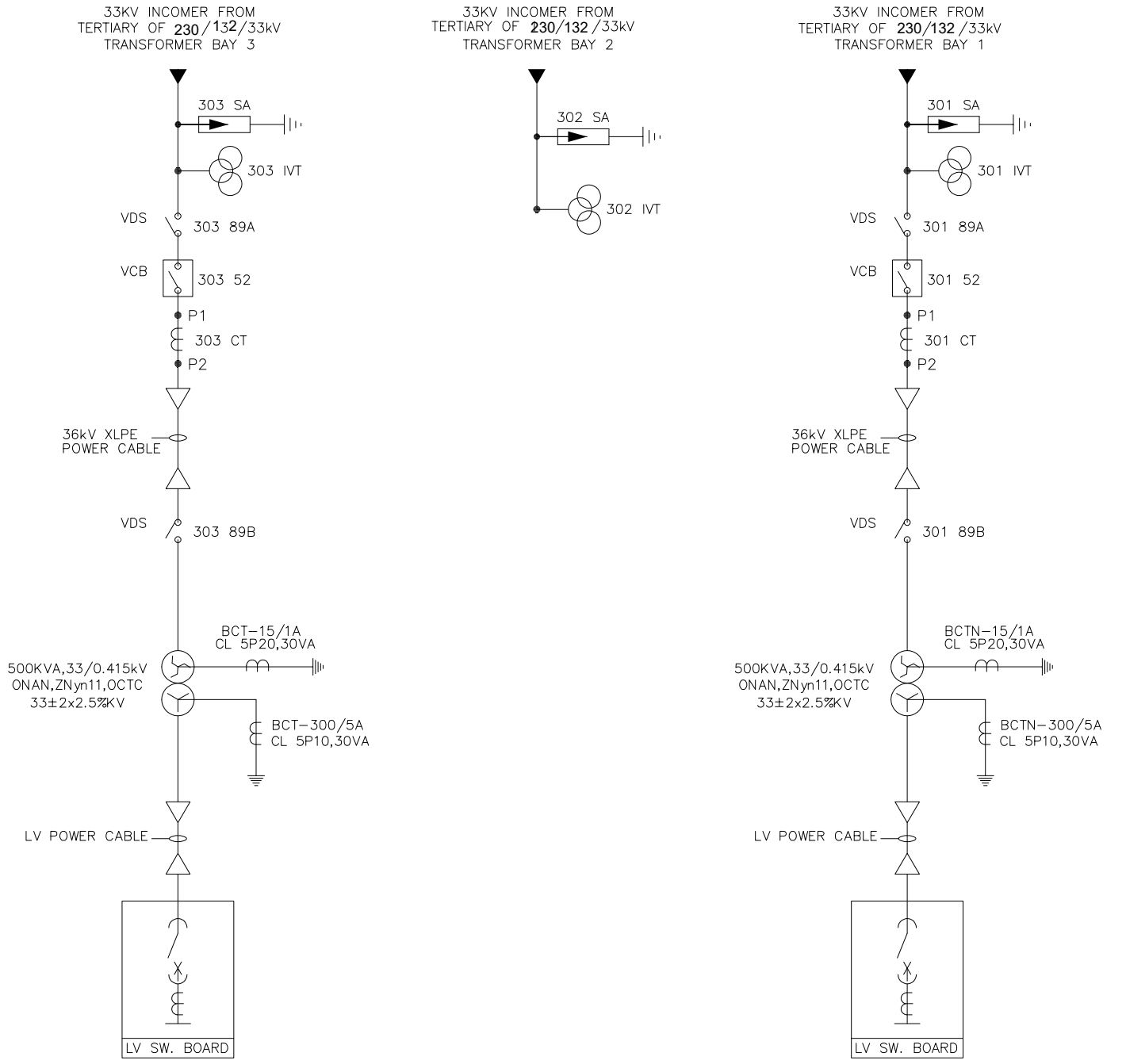
PROJECT: Design, Supply, Installation, Testing & Commissioning of Substation for Mid Substation of Mechelpur and Monohardi including two nos. 132KV bay extension at Baijpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-3)

OWNER: POWER GRID BANGLADESH PLC

	DATE	NAME	SIGN.	TITLE:
DRAWN:				MONOHARDI 33kV OVERALL SLD

DWG. NO.: PGA06/SLD-3

SCALE: NTS SHEET: 1 OF 1



NOTE:

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3. Any rating of Equipment please follow Schedule A

The drawing is Prelimilinary & is for Bidding Purpose Only

REV.	DATE	DESCRIPTION	BY	MEC.	ELE.	CIV.	C&I	SES	APPD.

PROJECT:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
OWNER:	POWER GRID BANGLADESH PLC
EPC CONTRACTOR:	Tender Purpose only

	DATE	NAME	SIGN.
DRAWN			

TITLE: Madhabpur Tertiary single line diagram

DEPARTMENT: ELECTRICAL

DRG. NO.: PG/ADB/SLD.4

SCALE: NTS | SHEET: 1 OF 2 | REV. C

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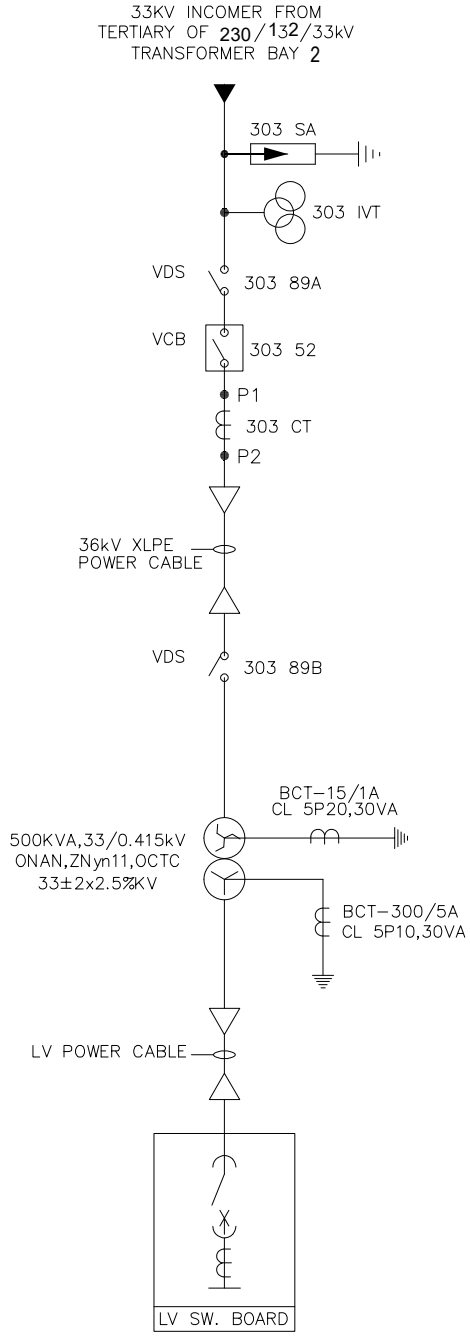
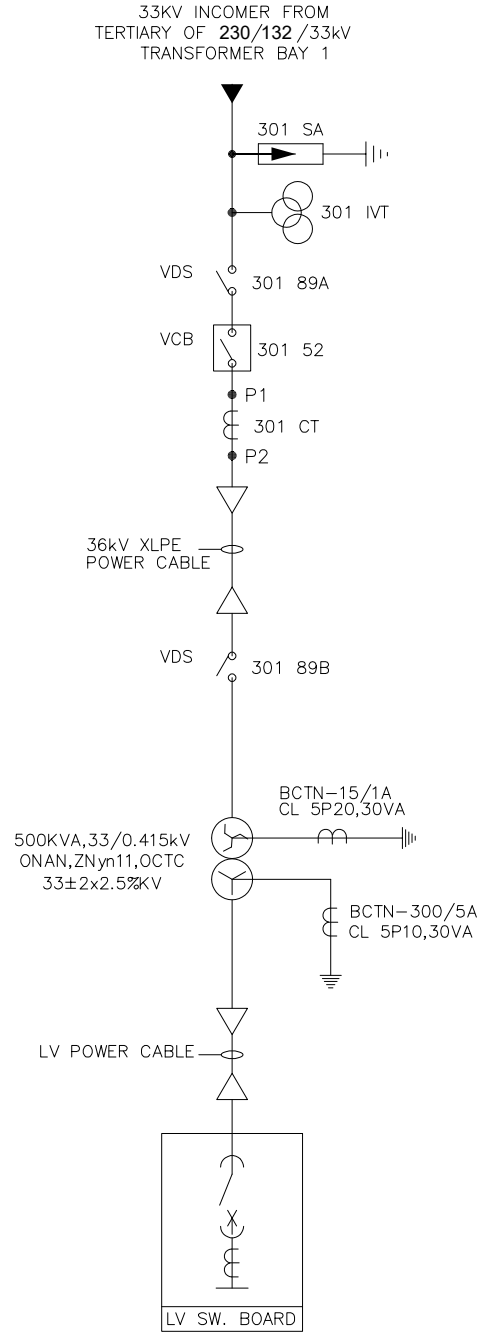
A0 (1189mm x 841mm)





NOTE:

1. ALL DS,ES ARE MOTOR OPERATED
2. GRAY DOTTED LINES INDICATE FUTURE BAYS
3. Any rating of Equipment please follow Schedule A

The drawing is Prelimilinary & is for Bidding Purpose Only

REV.	DATE	DESCRIPTION	BY	MEC.	ELE.	CIV.	C&I	SES	APPD.

PROJECT:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
OWNER:	POWER GRID BANGLADESH PLC
EPC CONTRACTOR:	Tender Purpose only

	DATE	NAME	SIGN.
DRAWN			

TITLE: Monohardi Tertiary single line diagram

DEPARTMENT: ELECTRICAL

DRG. NO.: PG/ADB/SLD.4

SCALE: NTS | SHEET: 1 OF 2 | REV. C

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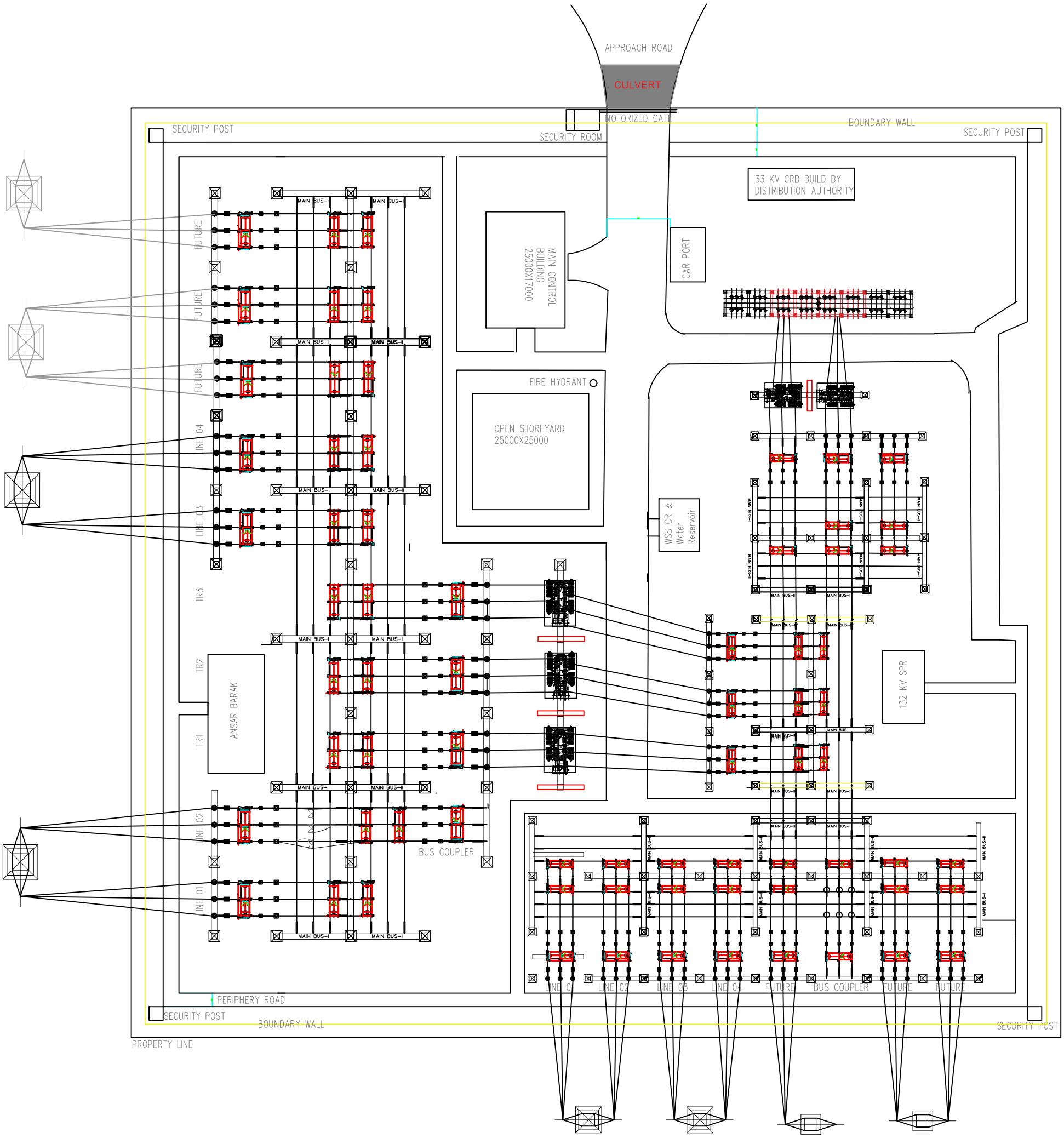
A0 (1189mm x 841mm)

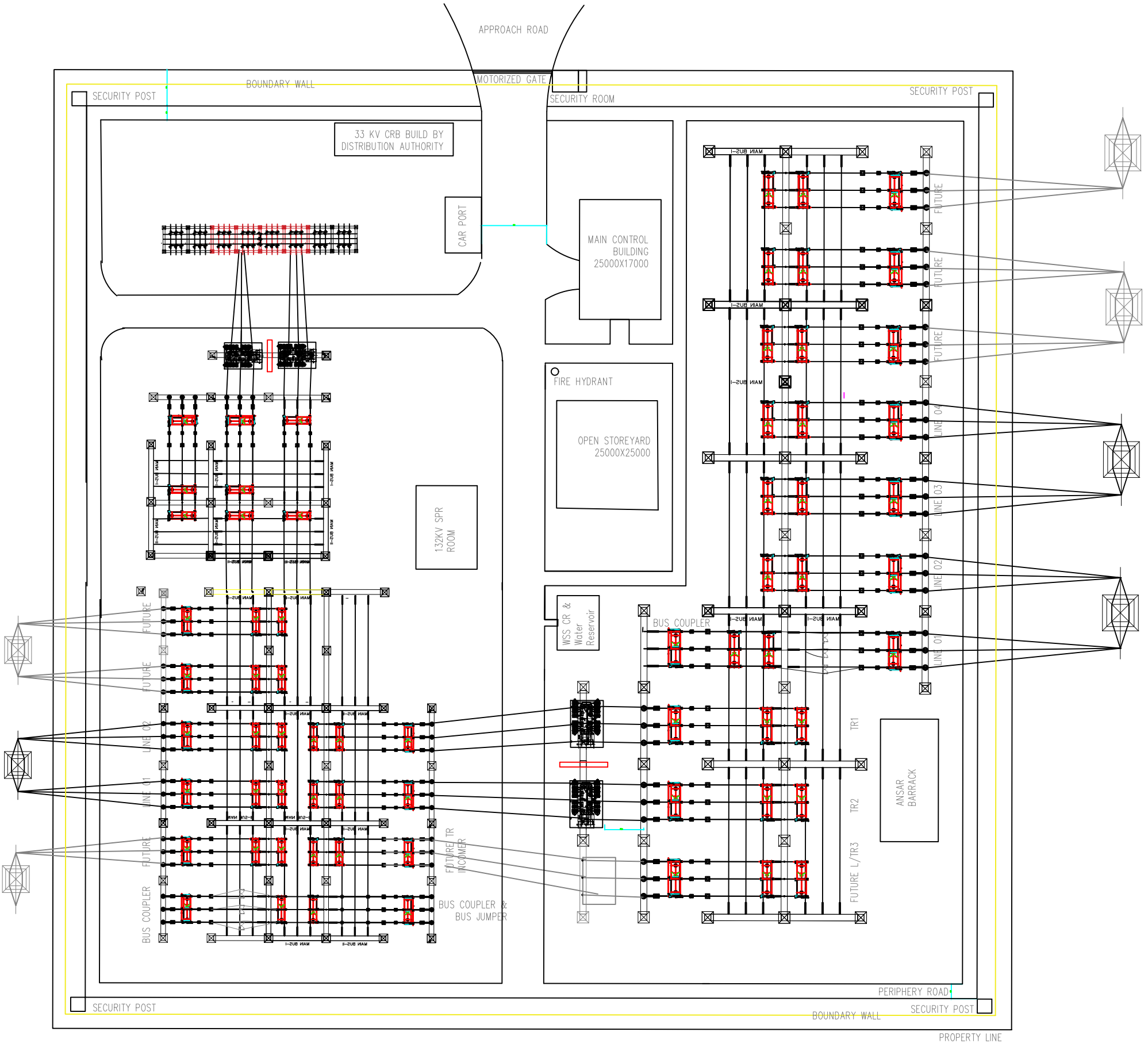


Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Title: MADHABPUR 230kV/132/33KV AIS SS LAYOUT

Drawing no: PG/ADB/LAY_all , Sheet 1 of 3



Tender Purpose Only
Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Title: Monohardi 230kV/132/33KV AIS SS LAYOUT
Drawing no: PG/ADB/LAY_all , Sheet 2 of 3

ALL DIMENSIONS ARE IN mm

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285267.107°E
2681240.027°N

285358.483°E
2681329.965°N

285356.065°E
2681334.950°N

285389.393°E
2681354.507°N

285469.930°E
2681291.294°N

285477.662°E
2681276.697°N

285353.371°E
2681155.152°N

285399.375°E
2681204.834°N

285410.901°E
2681213.313°N

To Kishoreganj

To Bazitpur

Bazitpur Road

167368

6750 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 12000 | 14618

PROPERTY LINE

ASHURGANJ-2 (BAY-01) | ASHURGANJ-1 (BAY-02) | TRX-1 (BAY-03) | TRX-2 (BAY-04) | KISHORGANJ-1 (BAY-05) | KISHORGANJ-2 (BAY-06) | BUS COUPLER (BAY-07) | LINE (FUTURE) (BAY-08) | TRX-3, (FUTURE) (BAY-09) | LINE (FUTURE) (BAY-10) | TRX-4, (FUTURE) (BAY-11) | LINE (FUTURE) (BAY-12)

BOUNDARY WALL

2000 | 3.0M WIDE ROAD | 2566 | 1683 | 5750 | 3733 | 3000 | 3500

3.0M WIDE ROAD

T-1 132/33kV, 80/120MVA

T-2 132/33kV, 80/120MVA

BLAST WALL

WATER SPRAY SYSTEM 8000x6000

T-3 132/33kV,

T-4 132/33kV,

6.0M WIDE ROAD

MAIN ENTRANCE GATE

4000 | 6000 | Car Parking | Car Parking

GUARD HOUSE 5000 | 2500 | 4000

AUX. TR-1 33/0.415kV, 200kVA

AUX. TR-2 33/0.415kV, 200kVA

33kV O/G (FUTURE-5) | 33kV O/G (FUTURE-6)

BUS DS

CT, ST, CB, DS, DS/ES & LA

BUS PT

Pump House

ST & FUTURE EQPT.

33kV O/G (FUTURE-1) | 33kV O/G (FUTURE-2) | 33kV O/G (FUTURE-3) | 33kV O/G (FUTURE-4) | 33kV O/G (FUTURE-7) | 33kV O/G (FUTURE-8)

ANSAR BARRACK (FUTURE)

28750 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 30000

33kV CONTROL BUILDING (FUTURE)

10000 | 12000

3.5M WIDE ROAD

GATE

LOW WIDE WALK WAY

8800 | 17600 | 8800 | 8000

8050 | 4000 | 4250 | 3800

SEPTIC TANK

BOUNDARY WALL

PROPERTY LINE

167645

5238 | 3251 | 5786 | 5750 | 2000

121017 | 109449

73000 | 16500 | 30535 | 10934

℄ LA | ℄ ST/CVT | ℄ DS/ES | ℄ CT | ℄ CB | ℄ ST | ℄ DS | ℄ CVT | ℄ DS | ℄ ST | ℄ DS | ℄ CVT | ℄ DS | ℄ ST | ℄ CB | ℄ CT | ℄ LA | ℄ TRX. | ℄ ST

4555 | 6026 | 12000 | 12000 | 12000 | 16500 | 5000 | 3000 | 6000 | 13000 | 10000 | 5000 | 13000

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing title: Bajitpur Bay extension
Drawing no: PG/ADB/LAY_all , Sheet 3 of 3

This approval is given based on Layout committee meeting minutes Ref: 27.21.0000.400.06.046. 20.4274 Dated: 22.10.2020

POWER GRID COMPANY OF BANGLADESH LTD
APPROVED WITH COMMENTS VIDE PGCB LETTER No. 20.321
This approval is general only and does not release the manufacturer/contractor/supplier from compliance with specification and standards for design, Workmanship and performance as stipulated in the contract.

(Shafi Hasan Jamil) Sub-Divisional Engineer Design & Quality Control PGCB Ltd

(Khaled Iftekhar) Executive Engineer Design & Q C (Substation) PGCB Ltd ID No. 00329

(Syed Abadullah Haider Ali) ID NO: 04227 superintending Engineer Substation Design & Quality Control PGCB Ltd.

16 NOV 2020

REV.	DATE	DESCRIPTION	DRAWING	DESIGNED	CHECKED	APPROVED
01	13.10.2020					
00	10.08.2020	FOR APPROVAL	S. I.	N. M.	N. M.	R. A.

CONTRACT DOCUMENT FOR:
Design, Supply, Installation, Testing & Commissioning of 132/33kV Substations, on Turnkey Basis Under The Energy Efficiency in Grid-based Power Supply Project (Package 2.1).

Contract No.: PGCB/KfW/BMZ.2014.67.976/2018/Package-2.1

EMPLOYER : POWER GRID COMPANY OF BANGLADESH LIMITED (PGCB)

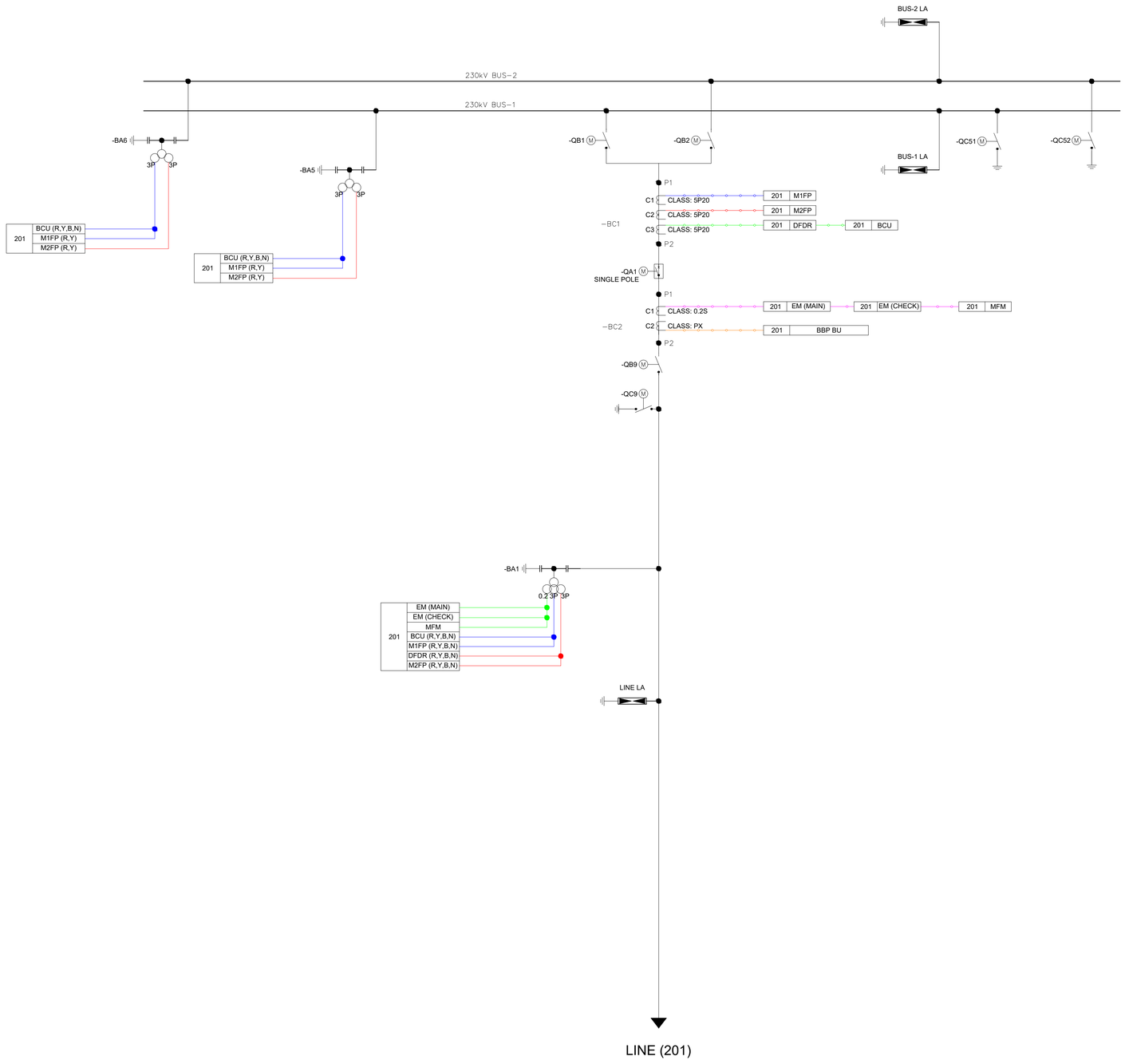
SUBSTATION NAME : BAJITPUR 132/33kV AIS SUBSTATION.

CONTRACTOR : seccoIII - Energypac Consortium

SCALE	1:450
DRAWN	S. I
CHECKED	N. M.
APPROVED	N. M.
DATE	10.08.2020

TITLE : OVERALL LAYOUT DRAWING OF BAJITPUR 132/33kV, AIS SUB-STATION.

DRAWING NO. : 3320/PGCB/KfW/BMZ/2.1/8 | SHT : 1 OF 1 | REV : 1



201	M1FP	
	MAIN-1 FEEDER PROTECTION	
	87L	51/51N
	21	50/50N
	21/85	46BC
	67N/85	27
	SOTF	59
	68	79 (QA1)
	VTFF	25 (QA1)
	21FL	DDR
	67/67N	

201	M2FP	
	MAIN-2 FEEDER PROTECTION	
	87L	51/51N
	21	50/50N
	21/85	46BC
	67N/85	27
	SOTF	59
	68	79 (QA1)
	VTFF	25 (QA1)
	21FL	DDR
	67/67N	

201	BCU	
	BAY CONTROL UNIT	
	kV	25 (QA1)
	A	CONTROL
	MW	INTERLOCK
	MVAR	

201	EM (MAIN)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

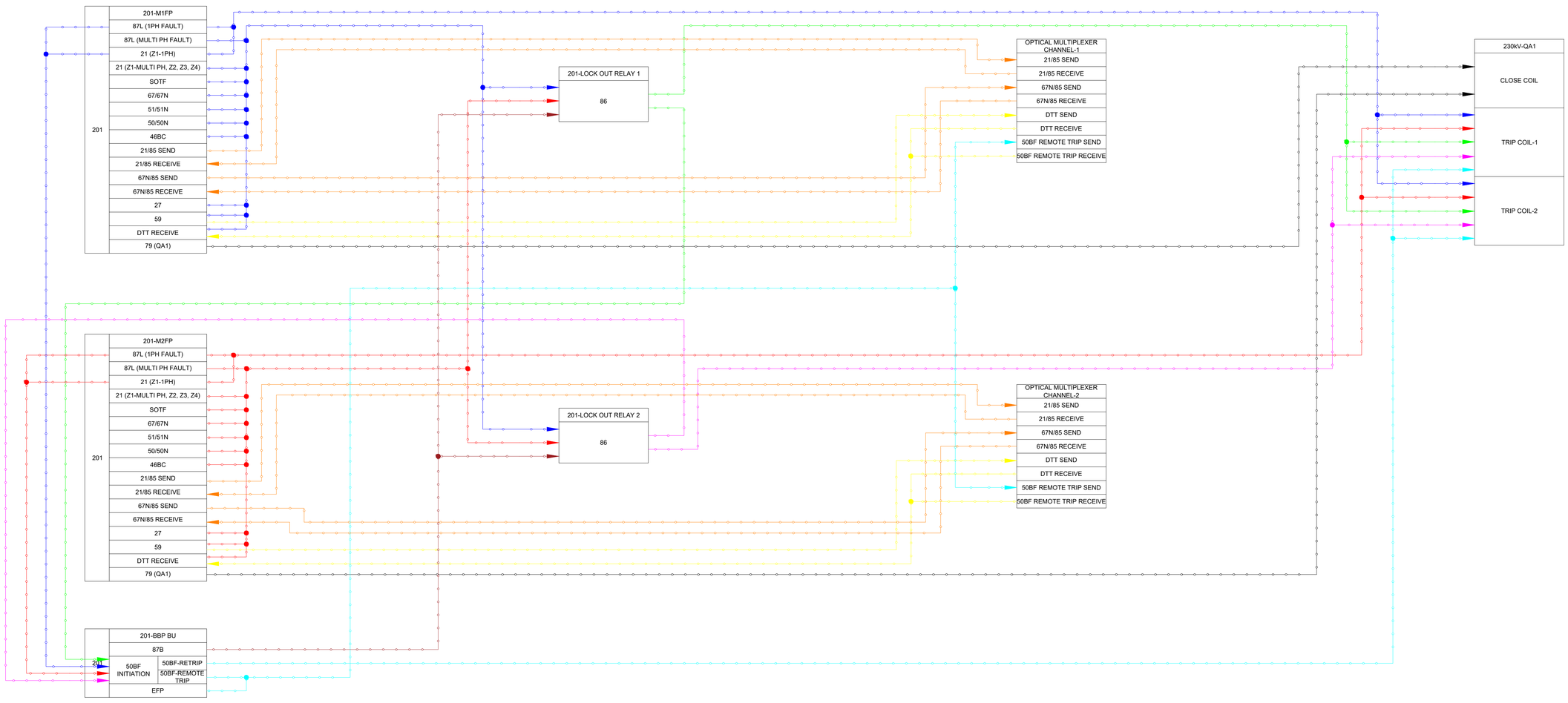
201	EM (CHECK)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

201	MFM	
	MULTIFUNCTION METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

201	BBP BU	
	BUSBAR PROTECTION BAY UNIT	
	87B	50BF
	EFP	

NOTES:

1. Busbar rating and equipment selection will be followed by Fault Level and Load Flow study for the specific substation.
2. 87L protection function in M1FP and M2FP of LINE feeder is optional for Long and Medium length lines; Definition of Long, Medium and Short length line is based on Clause 5.2 of IEEE Std. C37.113™-2015. Availability of 87L functions will be based on respective clause mentioned in the Tender document and Scope of Work.
3. 50BF functions will be activated for 2 stages: Re-trip to the same CB and Remote trip to the other sources.
4. 21/85 (Communication aided distance protection) and 67N/85 (Communication aided DEF protection) should be activated as per scheme selection in the particular relay.
5. 79 functions will be disabled for U/G cable feeders.
6. In normal condition, 79 function of 201-M1FP will be used for QA1. 79 function of 201-M2FP will be used in case of unhealthiness of 201-M1FP.
7. 25 functions of 201-M2FP relay will be used for MIMIC controls of the CB.
8. 25 functions of BCU will be used for BCU controls of the CB.
9. DTT from remote end of the LINE feeder will be received by M1FP and M2FP to provide tripping to the respective CBs.
10. Busbar Protections should be decentralized in principle.
11. For 50BF Remote Trip of Bus CBs, tripping will be issued to all CBs connected to the respective Busbar; the trip logic will be implemented internally with BBP Central Unit.
12. Optical Multiplexer based communication should be established between both end substations of the LINE feeder.
13. Main-1 and Main-2 LINE protection relays, BBP relays and BFP relays should preferably of different manufacturer. Alternatively, different model of the same manufacturer.
14. Class of protective core of Current Transformers will follow the specifications mentioned in the approved Overall Single Line Diagram, Layout drawing and Current Transformer GTP. The class shown here is for demonstrating the secondary connections only.
15. Type of Voltage Transformers can be either CVT or IVT as mentioned in the approved Overall Single Line Diagram, Layout drawing and Voltage Transformer GTP. The type shown here is for demonstrating the secondary connections only.
16. This document is for conceptualization of protection philosophy. Actual layout and arrangement of the High-voltage equipment may differ depending on the particular substation.
17. Any aspect mentioned in the Standard Document may be superseded by the Tender document and Scope of Work depending on specific application.



VOLTAGE LEVEL	230kV
BUS ARRANGEMENT	DOUBLE BUS
SUBSTATION TYPE	AIS
FEEDER ARRANGEMENT/ TYPE	LINE

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: 230 kV Line & Bus Protection
Drawing No: PG/ADB/LP_230kV

REVISION	DATE	REMARKS
0	27.06.2021	FIRST PREPARATION

STANDARD DOCUMENT NUMBER: 08

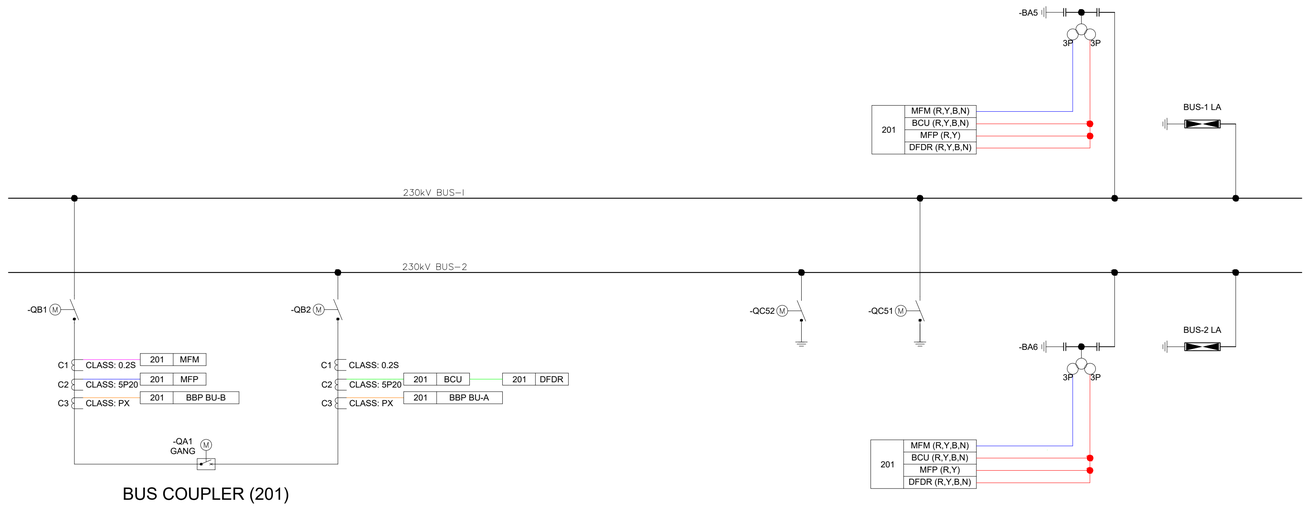
POWER GRID BANGLADESH PLC

TITLE: PROTECTION SLD & TRIP LOGIC OF 230kV AIS SUBSTATION WITH DOUBLE BUS ARRANGEMENT FOR LINE FEEDER

DOCUMENT ID: DO–DB–GO–LN–PSLD

SHEET 1

NEXT SHT N/A



BUS COUPLER (201)

201	MFP
	MAIN FEEDER PROTECTION
	51/51N / DDR
	50/50N / 25 (QA1)

201	BCU
	BAY CONTROL UNIT
	kV / 25 (QA1)
	A / CONTROL
	MW / INTERLOCK
	MVAR

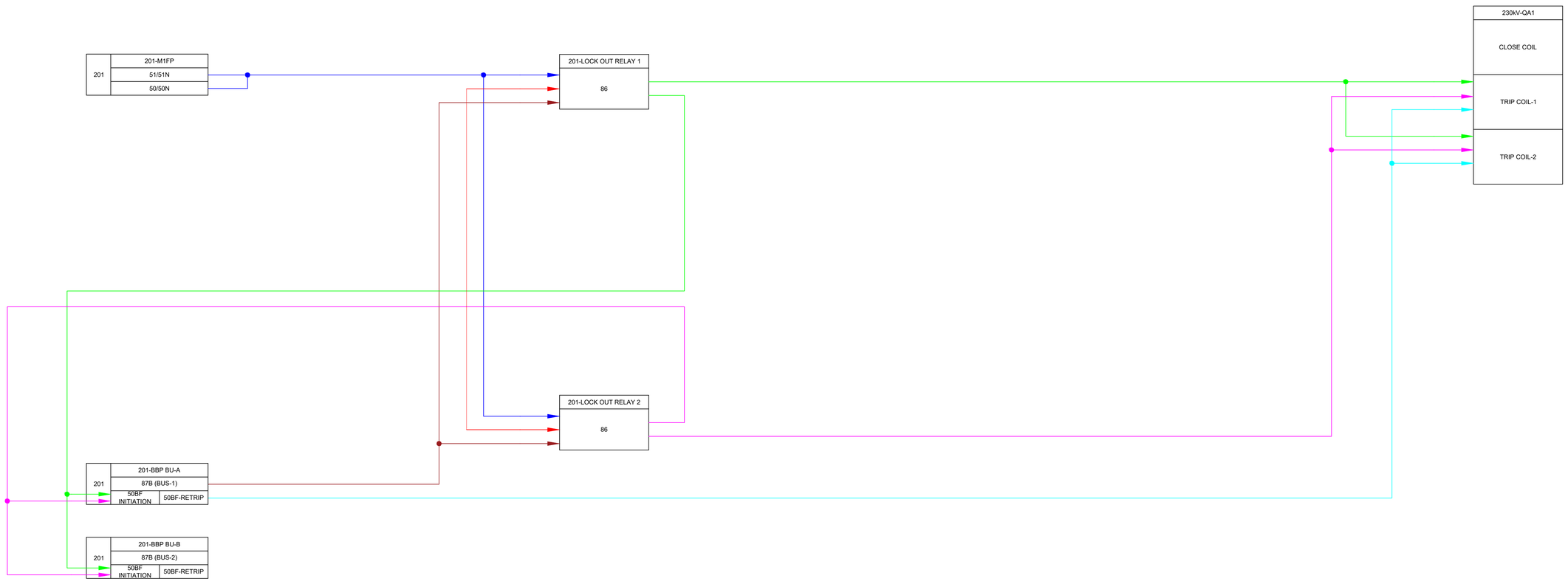
201	MFM
	MULTIFUNCTION METER
	kV / FREQ
	A / PF
	MW / kWh
	MVAR / kVARh

201	BBP BU-A
	BUSBAR PROTECTION BAY UNIT-A
	87B (BUS-1) / 50BF

201	BBP BU-B
	BUSBAR PROTECTION BAY UNIT-B
	87B (BUS-2) / 50BF

NOTES:

1. Busbar rating and equipment selection will be followed by Fault Level and Load Flow study for the specific substation.
2. 50BF functions will be activated for 1 stage: Re-trip to the same CB.
3. 25 functions of 201-MFP relay will be used for MIMIC controls of the CB.
4. 25 functions of BCU will be used for BCU controls of the CB.
5. Busbar Protections should be decentralized in principle.
6. For 50BF Remote Trip of Bus Coupler CB, tripping will be issued to all CBs connected to both Busbars; the trip logic will be implemented internally with BBP Central Unit.
7. BBP BU-B will be used for CT measurement for the respective Busbar. Tripping will be issued from BBP BU-A for both Bus Zone Trip.
8. Main-1 and Main-2 FEEDER protection relays should preferably of different manufacturer. Alternatively, different model of the same manufacturer.
9. Class of protective core of Current Transformers will follow the specifications mentioned in the approved Overall Single Line Diagram, Layout drawing and Current Transformer GTP. The class shown here is for demonstrating the secondary connections only.
10. Type of Voltage Transformers can be either CVT or IVT as mentioned in the approved Overall Single Line Diagram, Layout drawing and Voltage Transformer GTP. The type shown here is for demonstrating the secondary connections only.
11. This document is for conceptualization of protection philosophy. Actual layout and arrangement of the High-voltage equipment may differ depending on the particular substation.
12. Any aspect mentioned in the Standard Document may be superseded by the Tender document and Scope of Work depending on specific application.



VOLTAGE LEVEL	230kV
BUS ARRANGEMENT	DOUBLE BUS
SUBSTATION TYPE	AIS
FEEDER ARRANGEMENT/ TYPE	BUS COUPLER

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: 230 kV Bus Coupler Protection
Drawing No: PG/ADB/230kV_BC

REVISION	DATE	REMARKS
0	27.06.2021	FIRST PREPARATION

STANDARD DOCUMENT NUMBER: 13A

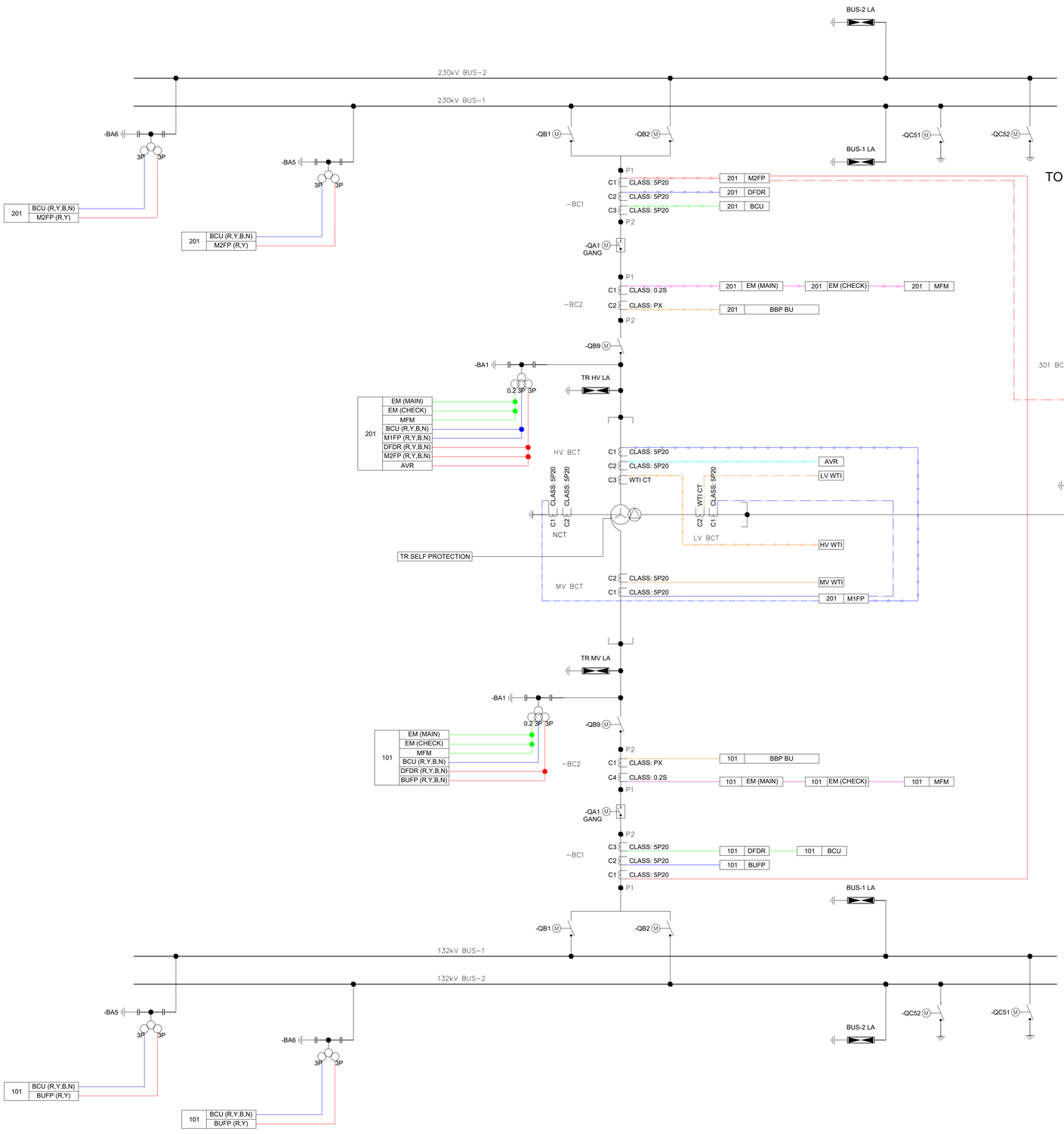
POWER GRID BANGLADESH PLC

TITLE: PROTECTION SLD & TRIP LOGIC OF 230kV AIS SUBSTATION WITH DOUBLE BUS ARRANGEMENT FOR BUS COUPLER FEEDER

DOCUMENT ID: D0-DB-G0-BC-PSLD

SHEET 1

NEXT SHT N/A



201	M1FP	
	MAIN-1 FEEDER PROTECTION	
	87T1	50/50N (LV)
	87N (LOW IMP)	24
	67/67N (HV)	27
	51/51N (HV)	59
	50/50N (HV)	DDR
	51/51N (LV)	

201	M2FP	
	MAIN-2 FEEDER PROTECTION	
	87T2	24
	67/67N (HV)	27
	51/51N (HV)	59
	50/50N (HV)	DDR
	25 (QA1)	

201	BCU	
	BAY CONTROL UNIT	
	kV	25 (QA1)
	A	CONTROL
	MW	INTERLOCK
	MVAR	

201	EM (MAIN)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

201	EM (CHECK)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

201	MFM	
	MULTIFUNCTION METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

201	BBP BU	
	BUSBAR PROTECTION BAY UNIT	
	87B	50BF
	EFP	

201	TR SELF PROTECTION	
	ALARM	TRIP
	HV-WTI	HV-WTI
	MV-WTI	MV-WTI
	LV-WTI	LV-WTI
	OTI-1	OTI-1
	OTI-2	OTI-2
	BUCHHOLZ (MAIN)	BUCHHOLZ (MAIN)
	BUCHHOLZ (OLTC)	BUCHHOLZ (OLTC)
	OIL LEVEL	PRD-1
		PRD-2
		OSR

101	BUFP	
	BACK-UP FEEDER PROTECTION	
	67/67N (MV)	27
	51/51N (MV)	59
	50/50N (MV)	DDR
	25 (MV-QA1)	

101	BCU	
	BAY CONTROL UNIT	
	kV	25 (MV-QA1)
	A	CONTROL
	MW	INTERLOCK
	MVAR	

101	EM (MAIN)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

101	EM (CHECK)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

101	MFM	
	MULTIFUNCTION METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

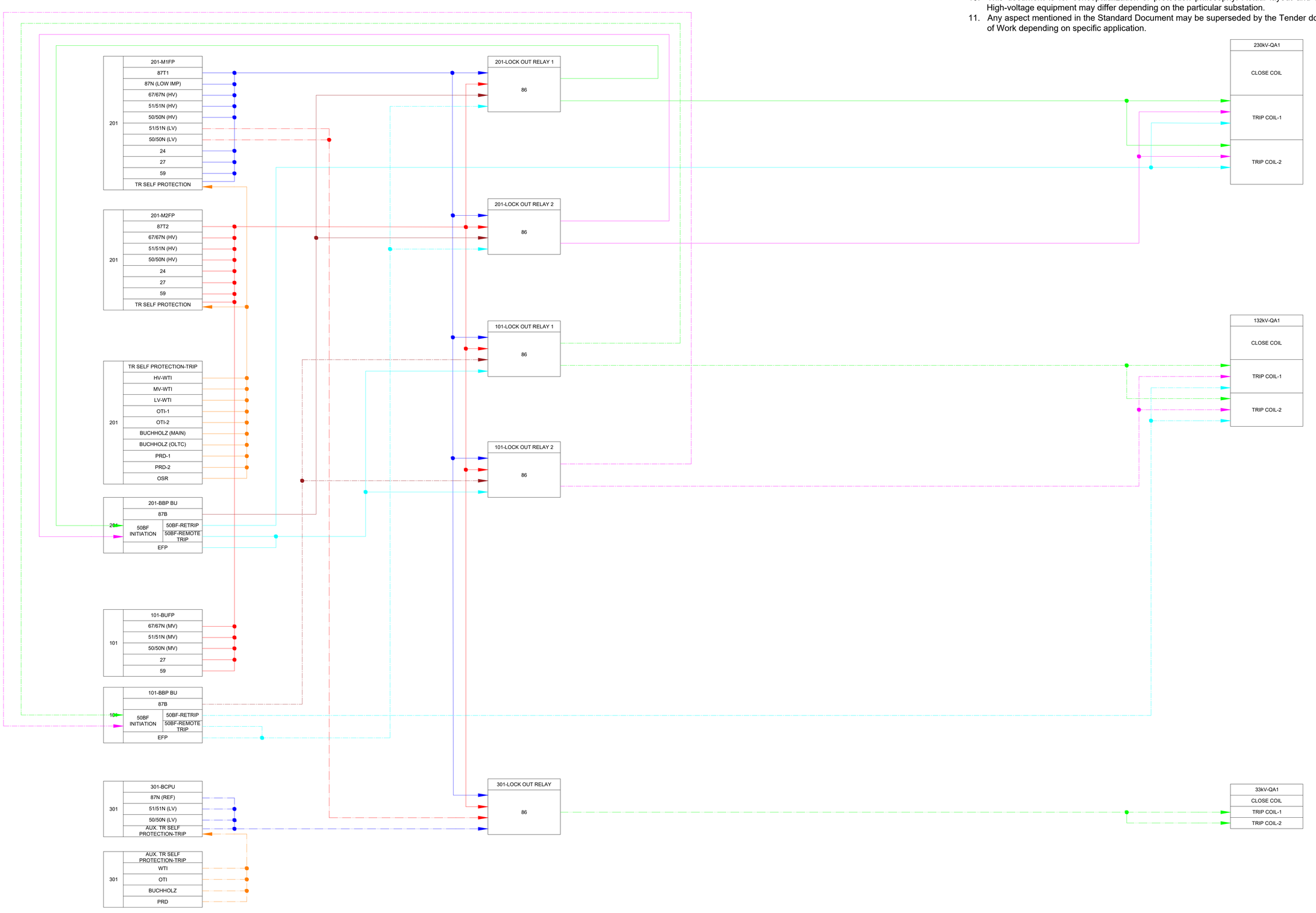
101	BBP BU	
	BUSBAR PROTECTION BAY UNIT	
	87B	50BF
	EFP	

301	BCPU	
	BAY CONTROL & PROTECTION UNIT	
	87N (REF)	kW
	51/51N (LV)	kVAR
	50/50N (LV)	CONTROL
	kV	INTERLOCK
	A	DDR

301	AUX. TR SELF PROTECTION	
	ALARM	TRIP
	WTI	WTI
	OTI	OTI
	BUCHHOLZ	BUCHHOLZ
	OIL LEVEL	PRD

NOTES:

1. Busbar rating and equipment selection will be followed by Fault Level and Load Flow study for the specific substation.
2. 50BF functions will be activated for 2 stages: Re-trip to the same CB and Remote trip to the other sources.
3. 25 function of 201-M2FP and 101-BUFP relays will be used for MIMIC controls of the respective CBs.
4. 25 functions of BCU will be used for BCU controls of the respective CBs.
5. Busbar Protections should be decentralized in principle.
6. For 50BF Remote Trip of Bus CBs, tripping will be issued to all CBs connected to the respective Busbar; the trip logic will be implemented internally with BBP Central Unit.
7. Main-1 and Main-2 Transformer protection relays, BBP relays and BFP relays should preferably of different manufacturer. Alternatively, different model of the same manufacturer.
8. Class of protective core of Current Transformers will follow the specifications mentioned in the approved Overall Single Line Diagram, Layout drawing and Current Transformer GTP. The class shown here is for demonstrating the secondary connections only.
9. Type of Voltage Transformers can be either CVT or IVT as mentioned in the approved Overall Single Line Diagram, Layout drawing and Voltage Transformer GTP. The type shown here is for demonstrating the secondary connections only.
10. This document is for conceptualization of protection philosophy. Actual layout and arrangement of the High-voltage equipment may differ depending on the particular substation.
11. Any aspect mentioned in the Standard Document may be superseded by the Tender document and Scope of Work depending on specific application.



VOLTAGE LEVEL	230kV
BUS ARRANGEMENT	DOUBLE BUS
SUBSTATION TYPE	AIS
FEEDER ARRANGEMENT/ TYPE	TRANSFORMER (3-WINDING)

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: 230 kV Tr Protection
Drawing No: PG/ADB/Trans_230

REVISION	DATE	REMARKS
1	15.08.2021	REVISED AS PER COMMENTS
0	27.06.2021	FIRST PREPARATION

STANDARD DOCUMENT NUMBER: 10

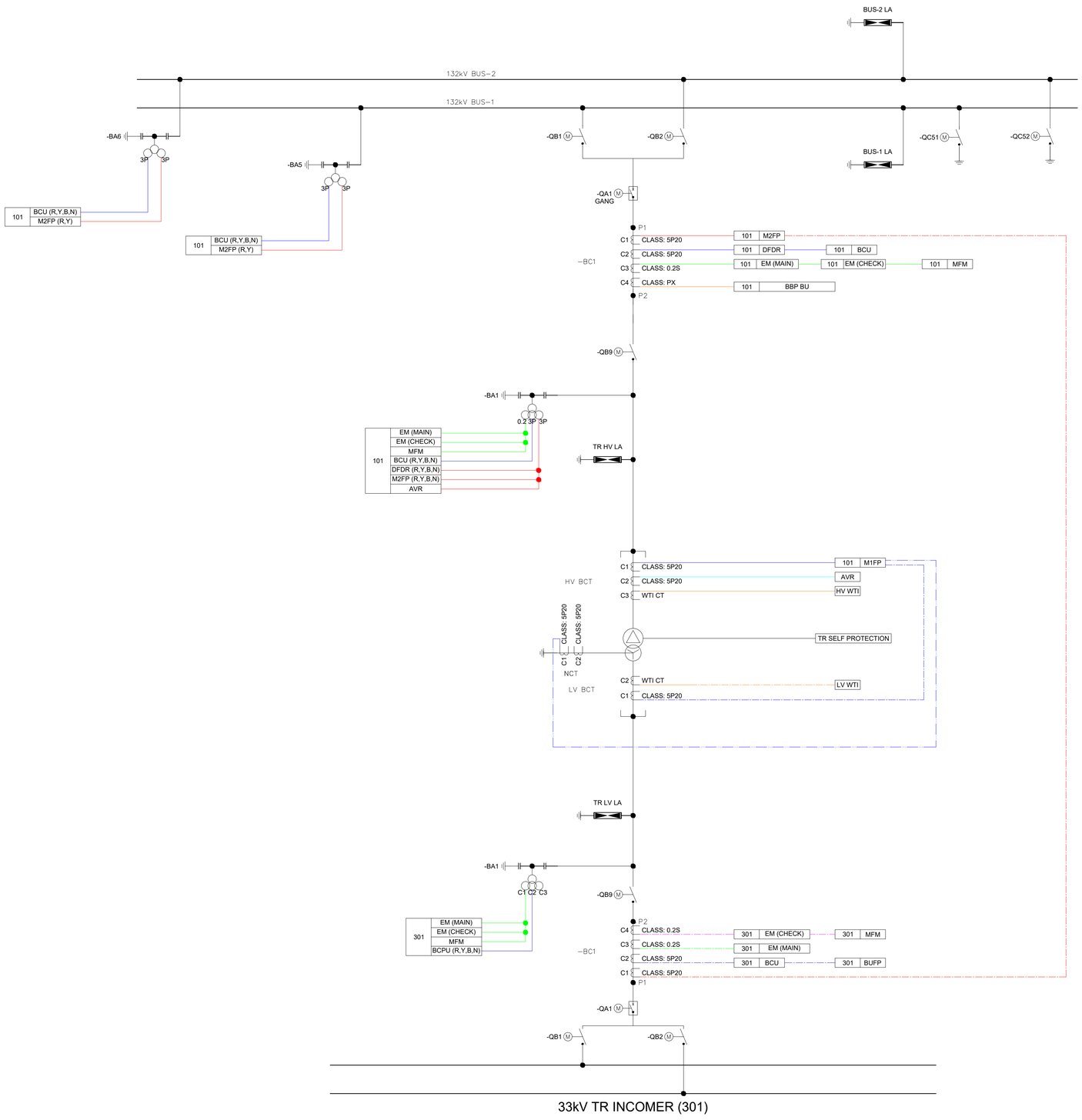
POWER GRID BANGLADESH PLC

TITLE: PROTECTION SLD & TRIP LOGIC OF 230kV AIS SUBSTATION WITH DOUBLE BUS ARRANGEMENT FOR TRANSFORMER (3W) FEEDER

DOCUMENT ID: D0-DB-G0-TR-PSLD

SHEET 1

NEXT SHT N/A



101	M1FP	
	MAIN-1 FEEDER PROTECTION	
	87T1	50/50N (HV)
	87N (LOW IMP)	24
	51/51N (HV)	DDR

101	M2FP	
	MAIN-2 FEEDER PROTECTION	
	87T2	24
	51/51N (HV)	27
	50/50N (HV)	59
	25 (QA1)	DDR

101	BCU	
	BAY CONTROL UNIT	
	kV	25 (QA1)
	A	CONTROL
	MW	INTERLOCK
	MVAR	

101	EM (MAIN)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

101	EM (CHECK)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

101	MFM	
	MULTIFUNCTION METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

101	BBP BU	
	BUSBAR PROTECTION BAY UNIT	
	87B	50BF
	EFP	

101	TR SELF PROTECTION	
	ALARM	TRIP
	HV-WTI	HV-WTI
	LV-WTI	LV-WTI
	OTI	OTI
	BUCHHOLZ (MAIN)	BUCHHOLZ (MAIN)
	BUCHHOLZ (OLTC)	BUCHHOLZ (OLTC)
	OIL LEVEL	PRD
		OSR

301	BCU	
	BAY CONTROL UNIT	
	kV	MVAR
	A	CONTROL
	MW	INTERLOCK

301	BUFP	
	BACK UP FEEDER PROTECTION	
	67/67N (LV)	27
	51/51N (LV)	59
	50/50N (LV)	DDR
	81O, 81U, 81R	

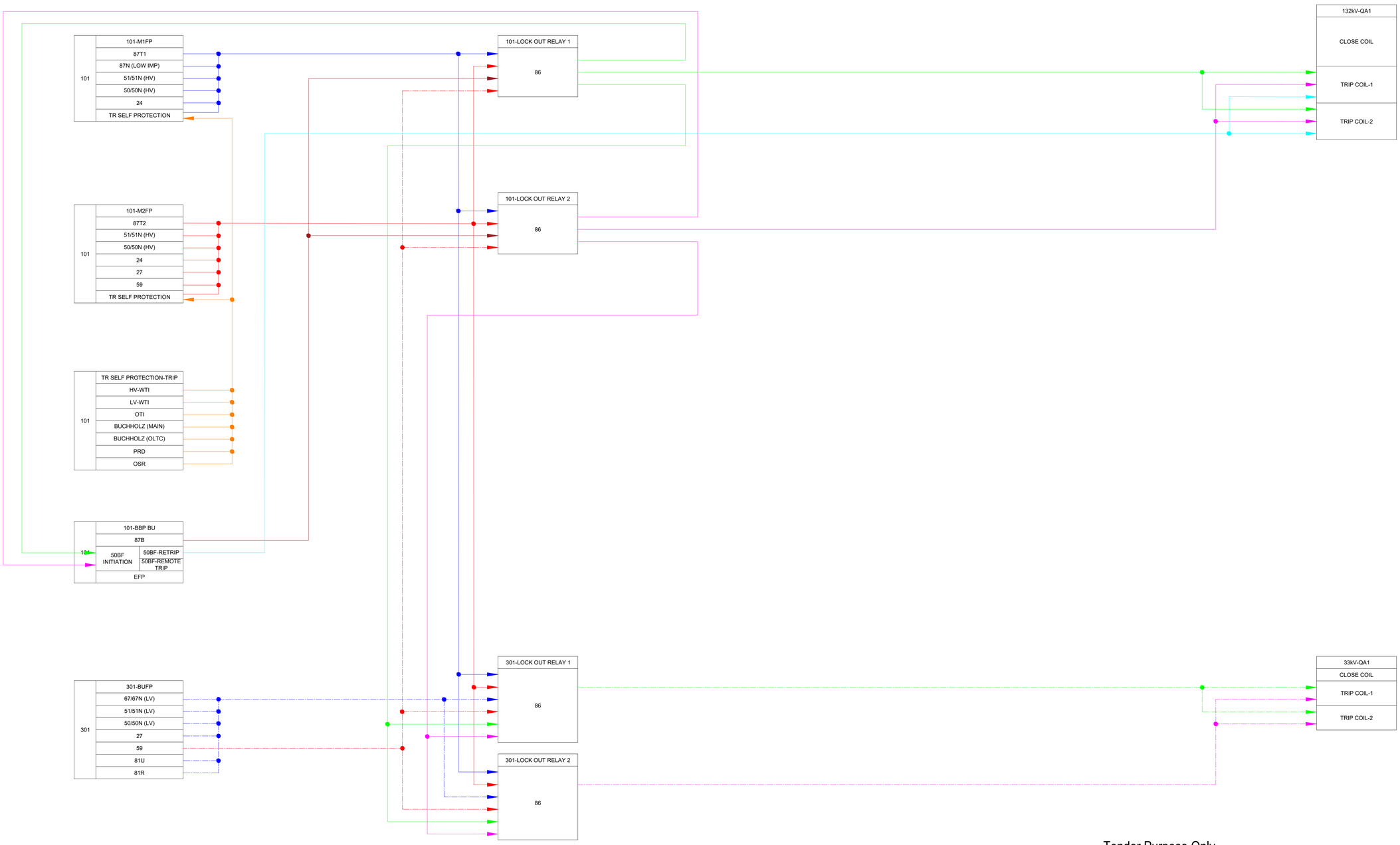
301	EM (MAIN)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

301	EM (CHECK)	
	ENERGY METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

301	MFM	
	MULTIFUNCTION METER	
	kV	FREQ
	A	PF
	MW	kWh
	MVAR	kVARh

NOTES:

1. Busbar rating and equipment selection will be followed by Fault Level and Load Flow study for the specific substation.
2. 50BF functions will be activated for 2 stages: Re-trip to the same CB and Remote trip to the other sources.
3. 25 function of 101-M2FP relays will be used for MIMIC controls of the respective CBs.
4. 25 functions of BCU will be used for BCU controls of the respective CBs.
5. Busbar Protections should be decentralized in principle.
6. For 50BF Remote Trip of Bus CBs, tripping will be issued to all CBs connected to the respective Busbar; the trip logic will be implemented internally with BBP Central Unit.
7. Main-1 and Main-2 Transformer protection relays, BBP relays and BFP relays should preferably of different manufacturer. Alternatively, different model of the same manufacturer.
8. Class of protective core of Current Transformers will follow the specifications mentioned in the approved Overall Single Line Diagram, Layout drawing and Current Transformer GTP. The class shown here is for demonstrating the secondary connections only.
9. Type of Voltage Transformers can be either CVT or IVT as mentioned in the approved Overall Single Line Diagram, Layout drawing and Voltage Transformer GTP. The type shown here is for demonstrating the secondary connections only.
10. This document is for conceptualization of protection philosophy. Actual layout and arrangement of the High-voltage equipment may differ depending on the particular substation.
11. Any aspect mentioned in the Standard Document may be superseded by the Tender document and Scope of Work depending on specific application.



VOLTAGE LEVEL	132kV
BUS ARRANGEMENT	DOUBLE BUS
SUBSTATION TYPE	AIS
FEEDER ARRANGEMENT/ TYPE	TRANSFORMER

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: 132 kV Tr Protection
Drawing No: PG/ADB/Trans_132

REVISION	DATE	REMARKS
0	26.07.2021	REVISED AS PER COMMENTS
0	27.06.2021	FIRST PREPARATION

STANDARD DOCUMENT NUMBER: 03

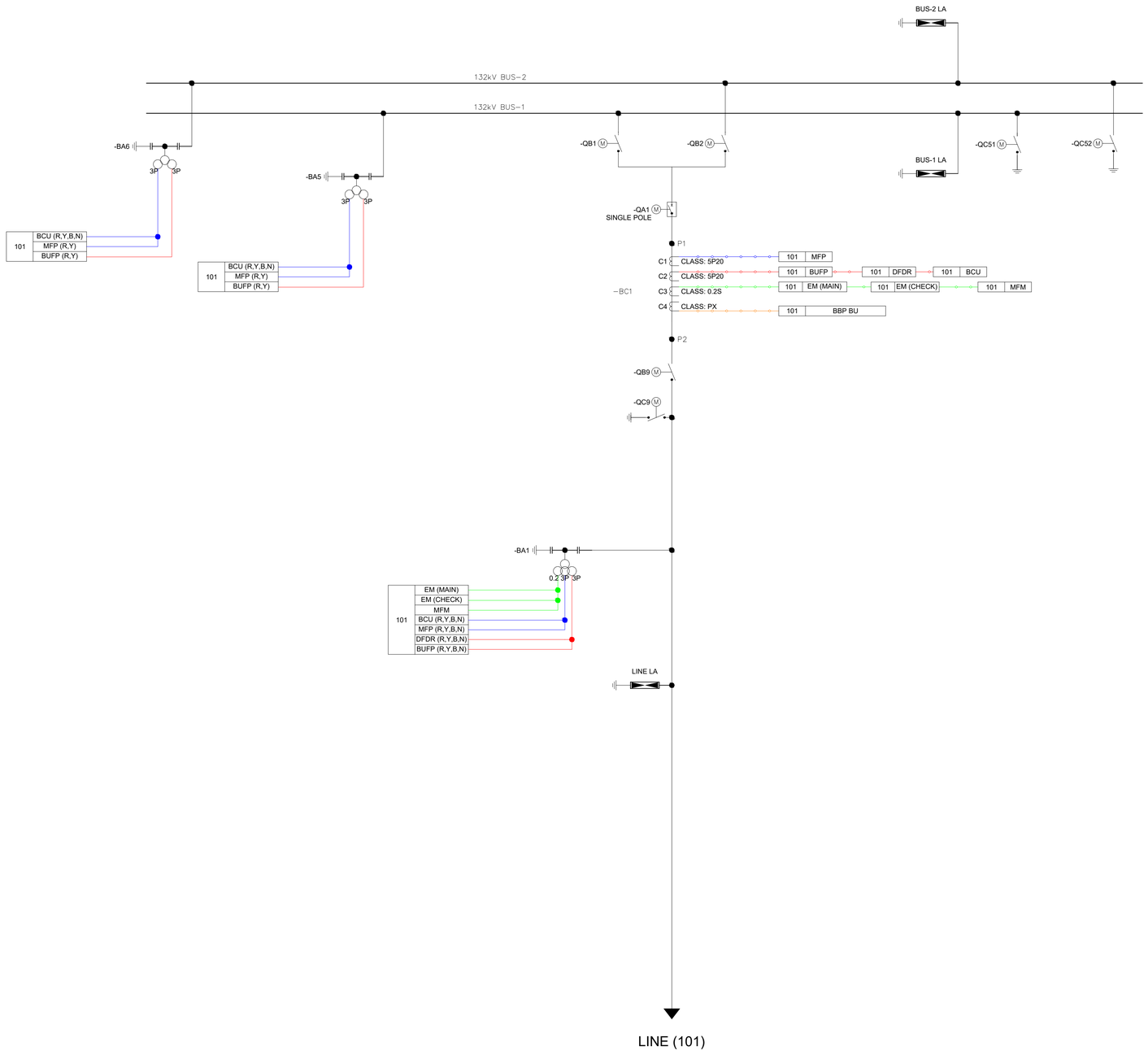
POWER GRID BANGLADESH PLC

TITLE: PROTECTION SLD & TRIP LOGIC OF 132kV AIS SUBSTATION WITH DOUBLE BUS ARRANGEMENT FOR TRANSFORMER FEEDER

DOCUMENT ID: E0-DB-A0-TR-PSLD

SHEET 1

NEXT SHT N/A



101	MFP
	MAIN FEEDER PROTECTION
	87L / 67/67N
	21 / 51/51N
	21/85 / 50/50N
	67N/85 / 46BC
	SOTF / 50STUB
	68 / 79 (QA1)
	VTFF / 25 (QA1)
	21FL / DDR

101	BUFP
	BACK UP FEEDER PROTECTION
	67/67N / 59
	51/51N / 25 (QA1)
	50/50N / DDR
	27

101	BCU
	BAY CONTROL UNIT
	kV / 25 (QA1)
	A / CONTROL
	MW / INTERLOCK
	MVAR

101	EM (MAIN)
	ENERGY METER
	kV / FREQ
	A / PF
	MW / kWh
	MVAR / kVARh

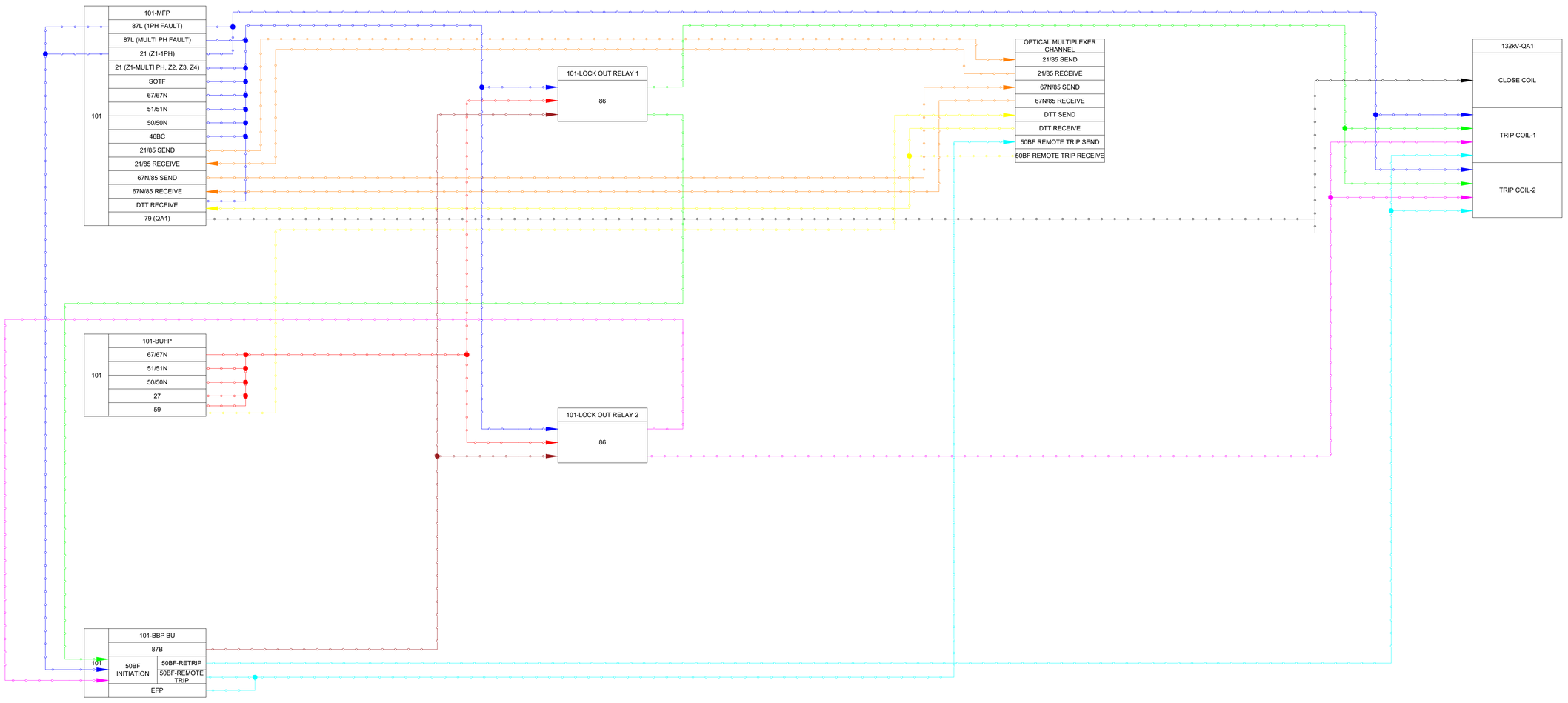
101	EM (CHECK)
	ENERGY METER
	kV / FREQ
	A / PF
	MW / kWh
	MVAR / kVARh

101	MFM
	MULTIFUNCTION METER
	kV / FREQ
	A / PF
	MW / kWh
	MVAR / kVARh

101	BBP BU
	BUSBAR PROTECTION BAY UNIT
	87B / 50BF
	EFP

NOTES:

1. Busbar rating and equipment selection will be followed by Fault Level and Load Flow study for the specific substation.
2. 87L protection function in MFP of LINE feeder is optional for Long and Medium length lines; Definition of Long, Medium and Short length line is based on Clause 5.2 of IEEE Std. C37.113^{TM}-2015. Availability of 87L functions will be based on respective clause mentioned in the Tender document and Scope of Work.
3. 50BF functions will be activated for 2 stages: Re-trip to the same CB and Remote trip to the other sources.
4. 21/85 (Communication aided distance protection) and 67N/85 (Communication aided DEF protection) should be activated as per scheme selection in the particular relay.
5. 79 function will be disabled for U/G cable feeders.
6. 25 functions of 101-BUFP relay will be used for MIMIC controls of the CB.
7. 25 functions of BCU will be used for BCU controls of the CB.
8. DTT from remote end of the LINE feeder will be received by MFP to provide tripping to the CB.
9. Busbar Protections should be decentralized in principle.
10. For 50BF Remote Trip of Bus CBs, tripping will be issued to all CBs connected to the respective Busbar; the trip logic will be implemented internally with BBP Central Unit.
11. Optical Multiplexer based communication should be established between both end substations of the LINE feeder.
12. Class of protective core of Current Transformers will follow the specifications mentioned in the approved Overall Single Line Diagram, Layout drawing and Current Transformer GTP. The class shown here is for demonstrating the secondary connections only.
13. Type of Voltage Transformers can be either CVT or IVT as mentioned in the approved Overall Single Line Diagram, Layout drawing and Voltage Transformer GTP. The type shown here is for demonstrating the secondary connections only.
14. This document is for conceptualization of protection philosophy. Actual layout and arrangement of the High-voltage equipment may differ depending on the particular substation.
15. Any aspect mentioned in the Standard Document may be superseded by the Tender document and Scope of Work depending on specific application.



VOLTAGE LEVEL	132kV
BUS ARRANGEMENT	DOUBLE BUS
SUBSTATION TYPE	AIS
FEEDER ARRANGEMENT/ TYPE	LINE

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: 132 kV Line & Bus Protection
Drawing No: PG/ADB/LP_132kV

REVISION	DATE	REMARKS
0	27.06.2021	FIRST PREPARATION

STANDARD DOCUMENT NUMBER: 01

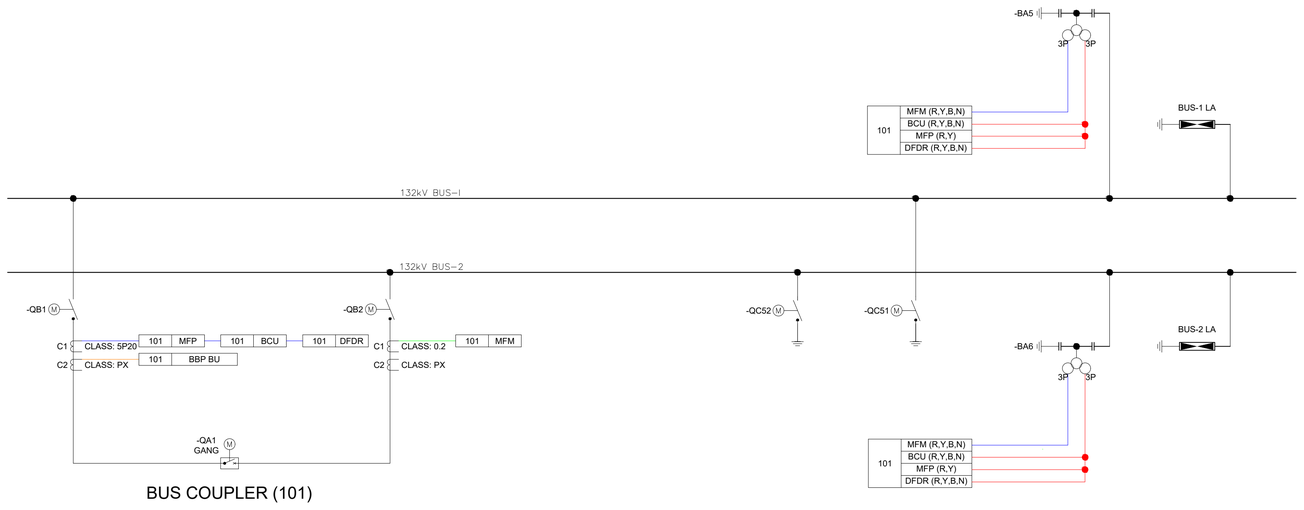
POWER GRID BANGLADESH PLC

TITLE: PROTECTION SLD & TRIP LOGIC OF 132kV AIS SUBSTATION WITH DOUBLE BUS ARRANGEMENT FOR LINE FEEDER

DOCUMENT ID: E0–DB–A0–LN–PSLD

SHEET 1

NEXT SHT N/A



BUS COUPLER (101)

101	MFP
	MAIN FEEDER PROTECTION
	51/51N / 25 (QA1)
	50/50N / DDR

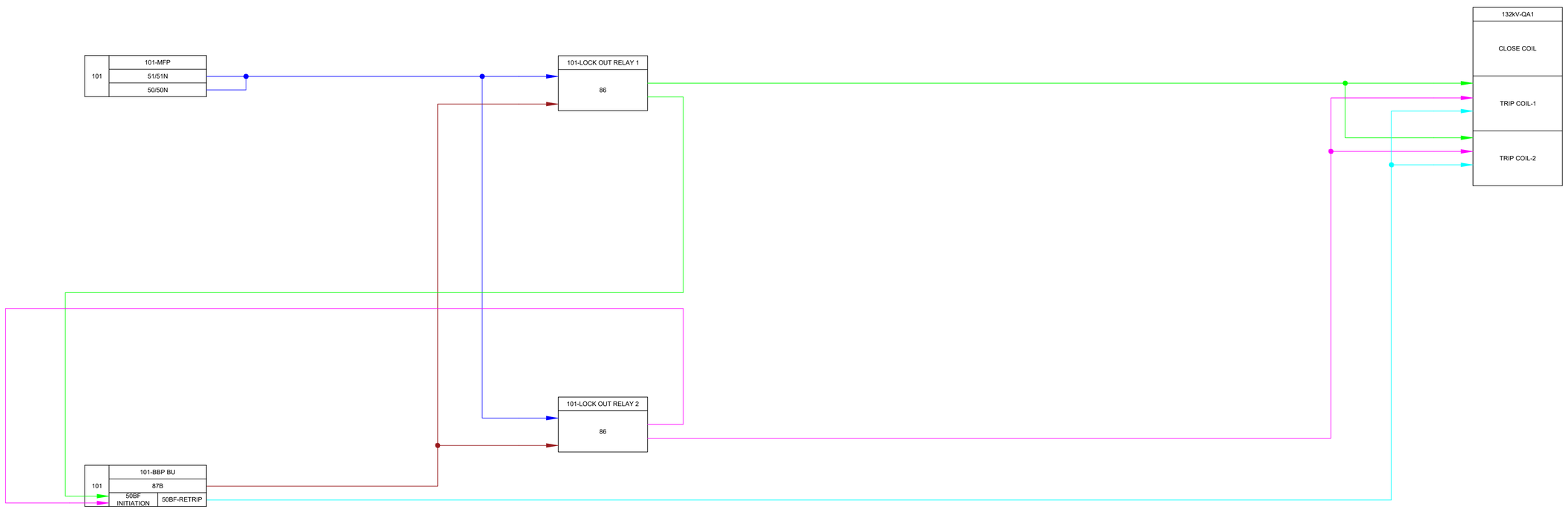
101	BBP BU
	BUSBAR PROTECTION BAY UNIT
	87B / 50BF

101	BCU
	BAY CONTROL UNIT
	kV / 25 (QA1)
	A / CONTROL
	MW / INTERLOCK
	MVAR /

101	MFM
	MULTIFUNCTION METER
	kV / FREQ
	A / PF
	MW / kWh
	MVAR / kVARh

NOTES:

1. Busbar rating and equipment selection will be followed by Fault Level and Load Flow study for the specific substation.
2. 50BF functions will be activated for 1 stage: Re-trip to the same CB.
3. 25 functions of 101-MFP relay will be used for MIMIC controls of the CB.
4. 25 functions of BCU will be used for BCU controls of the CB.
5. Busbar Protections should be decentralized in principle.
6. For 50BF Remote Trip of Bus Coupler CB, tripping will be issued to all CBs connected to both Busbars; the trip logic will be implemented internally with BBP Central Unit.
7. BBP BU-B will be used for CT measurement for the respective Busbar. Tripping will be issued from BBP BU-A for both Bus Zone Trip.
8. Class of protective core of Current Transformers will follow the specifications mentioned in the approved Overall Single Line Diagram, Layout drawing and Current Transformer GTP. The class shown here is for demonstrating the secondary connections only.
9. Type of Voltage Transformers can be either CVT or IVT as mentioned in the approved Overall Single Line Diagram, Layout drawing and Voltage Transformer GTP. The type shown here is for demonstrating the secondary connections only.
10. This document is for conceptualization of protection philosophy. Actual layout and arrangement of the High-voltage equipment may differ depending on the particular substation.
11. Any aspect mentioned in the Standard Document may be superseded by the Tender document and Scope of Work depending on specific application.



VOLTAGE LEVEL	132kV
BUS ARRANGEMENT	DOUBLE BUS
SUBSTATION TYPE	AIS
FEEDER ARRANGEMENT/ TYPE	BUS COUPLER

Tender Purpose Only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title: 132 kV Bus Coupler Protection
Drawing No: PG/ADB132kV_BC

REVISION	DATE	REMARKS
1	16.08.2021	REVISED AS PER COMMENTS
0	27.06.2021	FIRST PREPARATION

STANDARD DOCUMENT NUMBER: 13

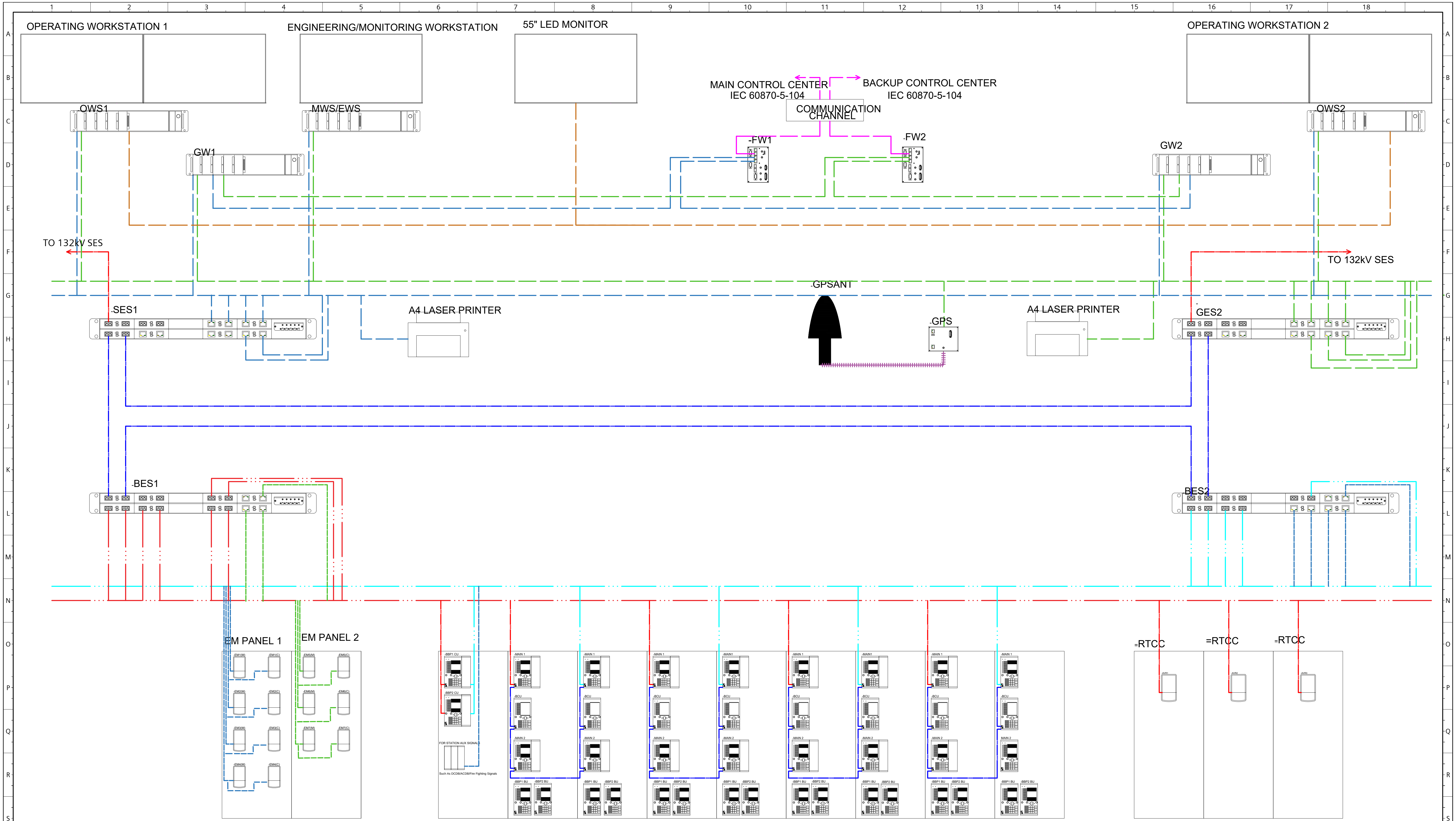
POWER GRID BANGLADESH PLC

TITLE: PROTECTION SLD & TRIP LOGIC OF 132kV SUBSTATION WITH DOUBLE BUS ARRANGEMENT FOR BUS COUPLER FEEDER

DOCUMENT ID: EO-DB-AG-BC-PSLD

SHEET 1

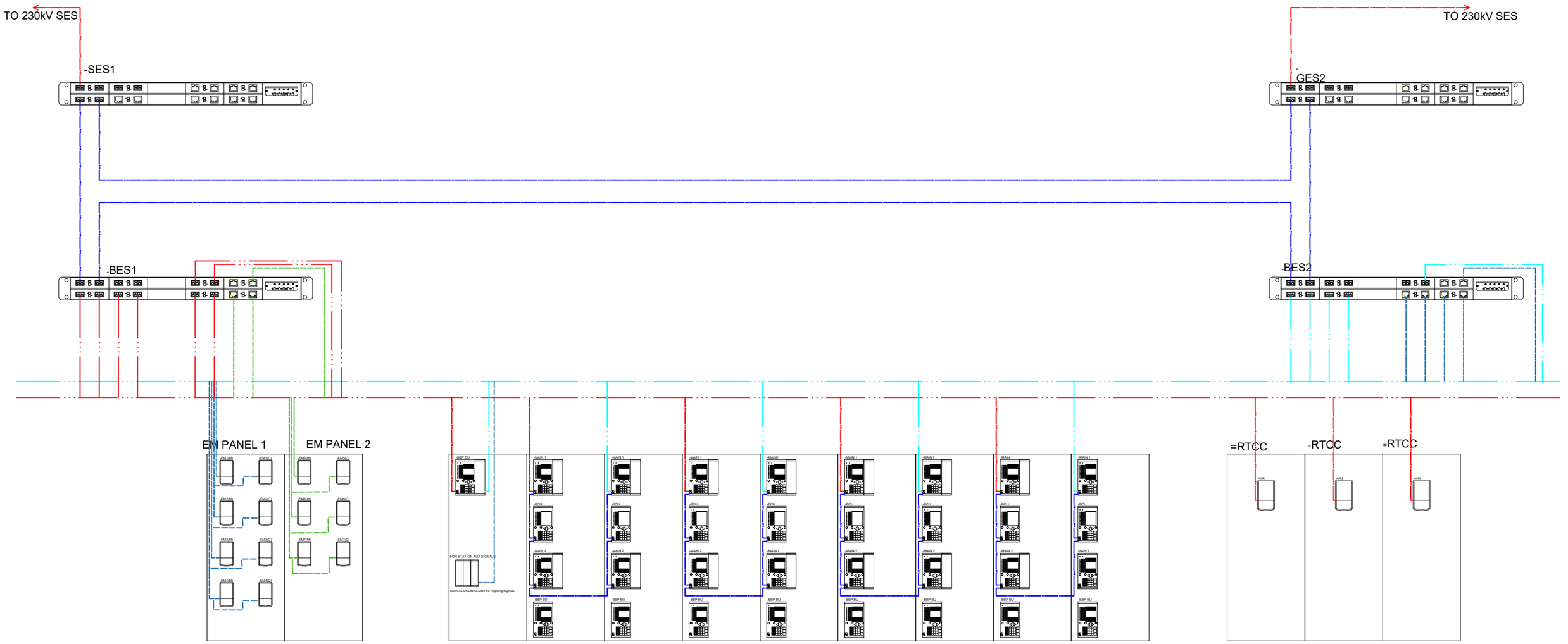
NEXT SHT N/A



Note: 1.Number of Panels and IEDs are indicative only. Final arrangement shall be as per contract schedule and standard practice in Power Grid. Note: 2.SAS Architecture shall be RSTP.
Note: 3.DFDR,PMU are not shown here. They shall be connected in separate standalone network.
Legend: SES- Station Level Ethernet Switch, BES- Bay Level Ethernet Switch.

Tender Purpose Only
Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing no: PG/ADB/SAS , Sheet 1 of 2

	POWER GRID BANGLADESH PLC	DESCRIPTION:- INDICATIVE NETWORK ARCHITECTURE	SCALE: N/A
			SHT: 1
For Tender Stage Only	CIRCUIT: 230 KV SUBSTATION AUTOMATION SYSTEM		
REMARKS	PROJECT:POWER TRANSMISSION STRENGTHENING AND INTEGRATION OF RENEWABLE ENERGY PROJECT (PTSIREP)		

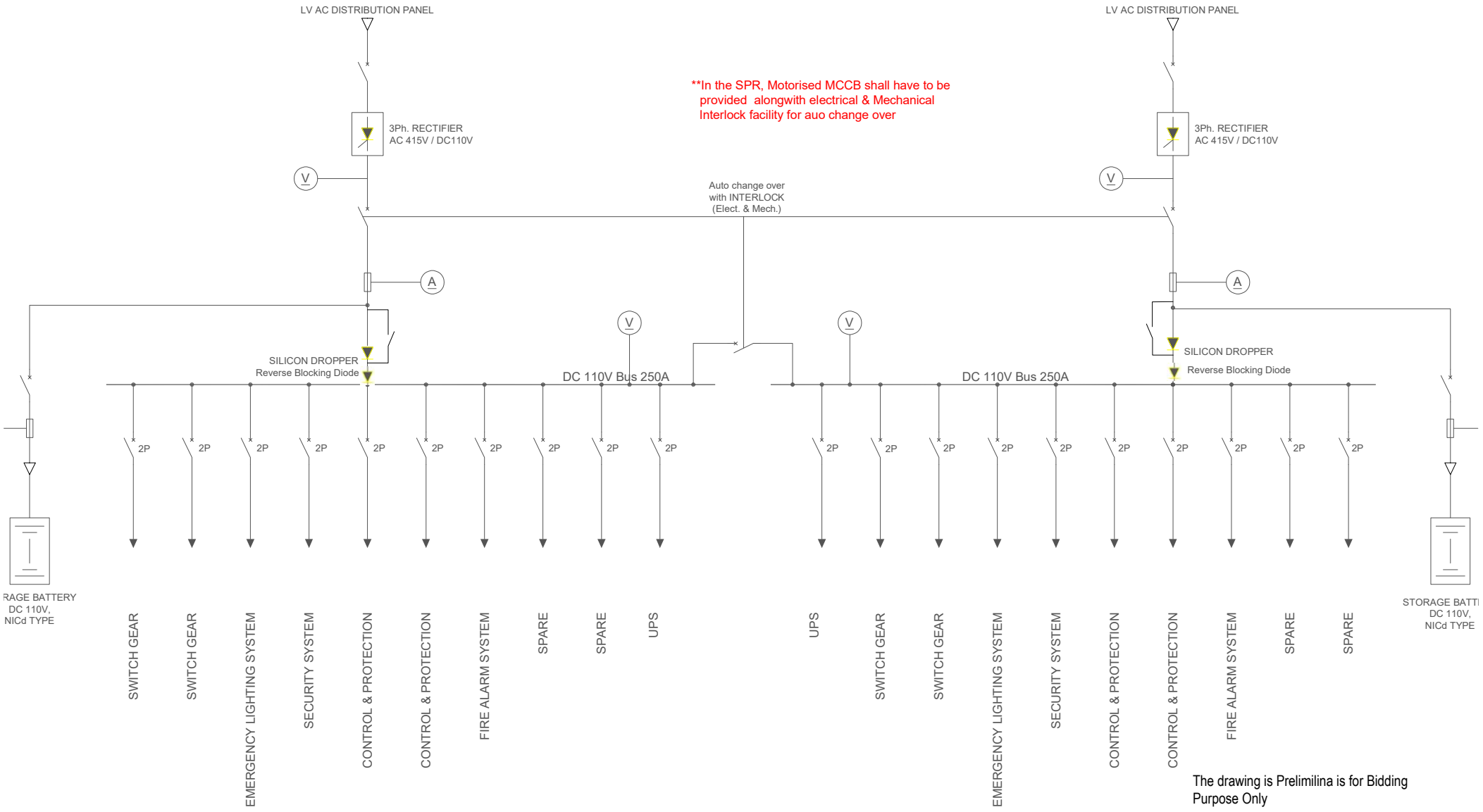


Note: 1.Number of Panels and IEDs are indicative only. Final arrangement shall be as per contract schedule and standard practice in Power Grid. Note: 2.SAS Architecture shall be RSTP.

Legend: SES- Station Level Ethernet Switch, BES- Bay Level Ethernet Switch.

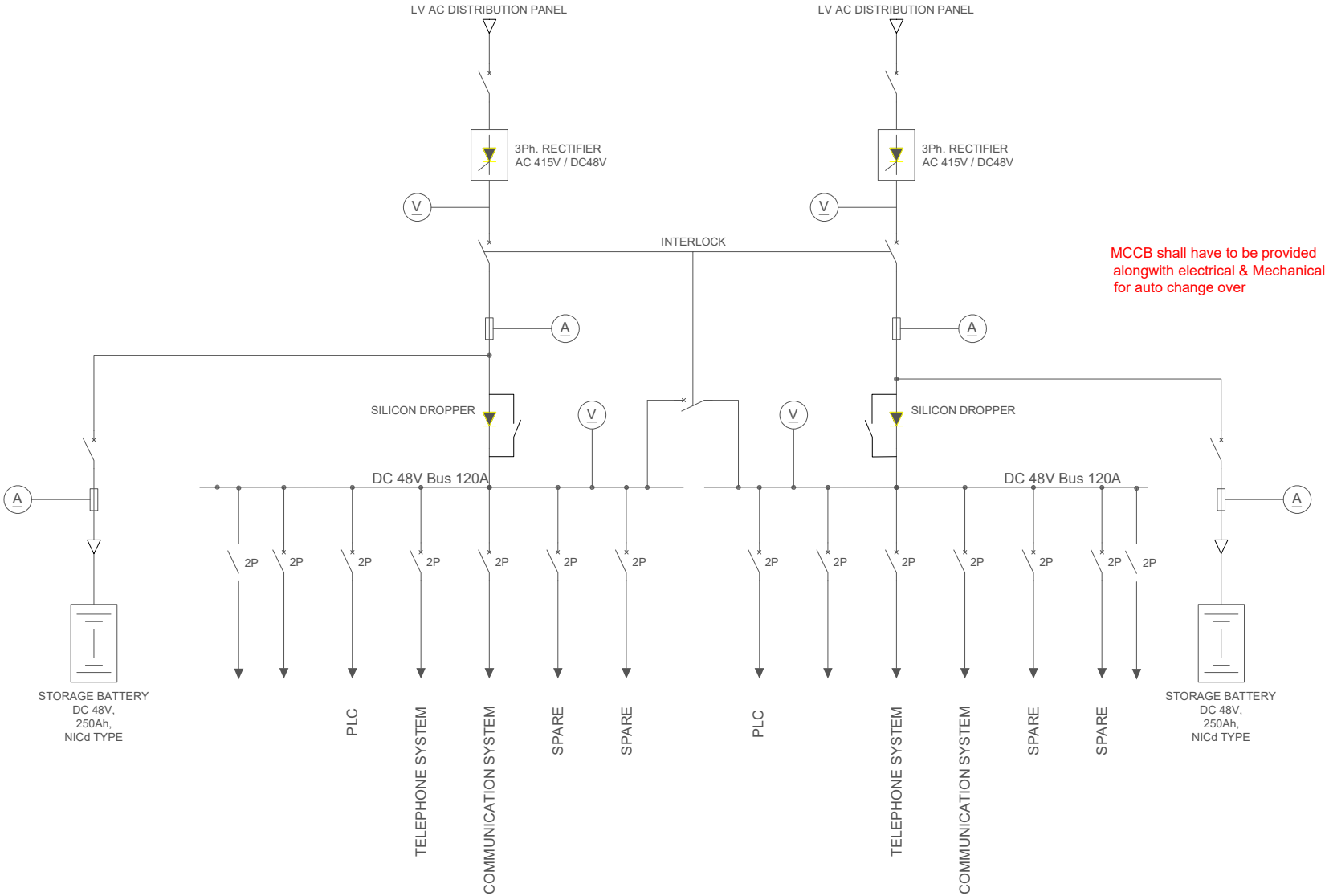
Tender Purpose Only
Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing no: PG/ADB/SAS , Sheet 2 of 2

					POWER GRID BANGLADESH PLC		DESCRIPTION:-			SCALE:	N/A
							INDICATIVE NETWORK ARCHITECTURE			SHT:	1
	For Tender Stage Only				CIRCUIT: 132 KV SUBSTATION AUTOMATION SYSTEM						
	REMARKS				PROJECT:POWER TRANSMISSION STRENGTHENING AND INTEGRATION OF RENEWABLE ENERGY PROJECT (PTSIREP)						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		



The drawing is Prelimilina is for Bidding Purpose Only

POWER GRID BANGLADESH PLC			
Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)			
Drawing Title	110V DC distribution scheme		
Drawing No.	PG/ADB/DC_110V		
Drawn:	Checked:	Approved:	
Department: Substation Design & Quality Control			



MCCB shall have to be provided alongwith electrical & Mechanical Interlock facility for auto change over

The drawing is Prelimilinary is for Bidding Purpose Only

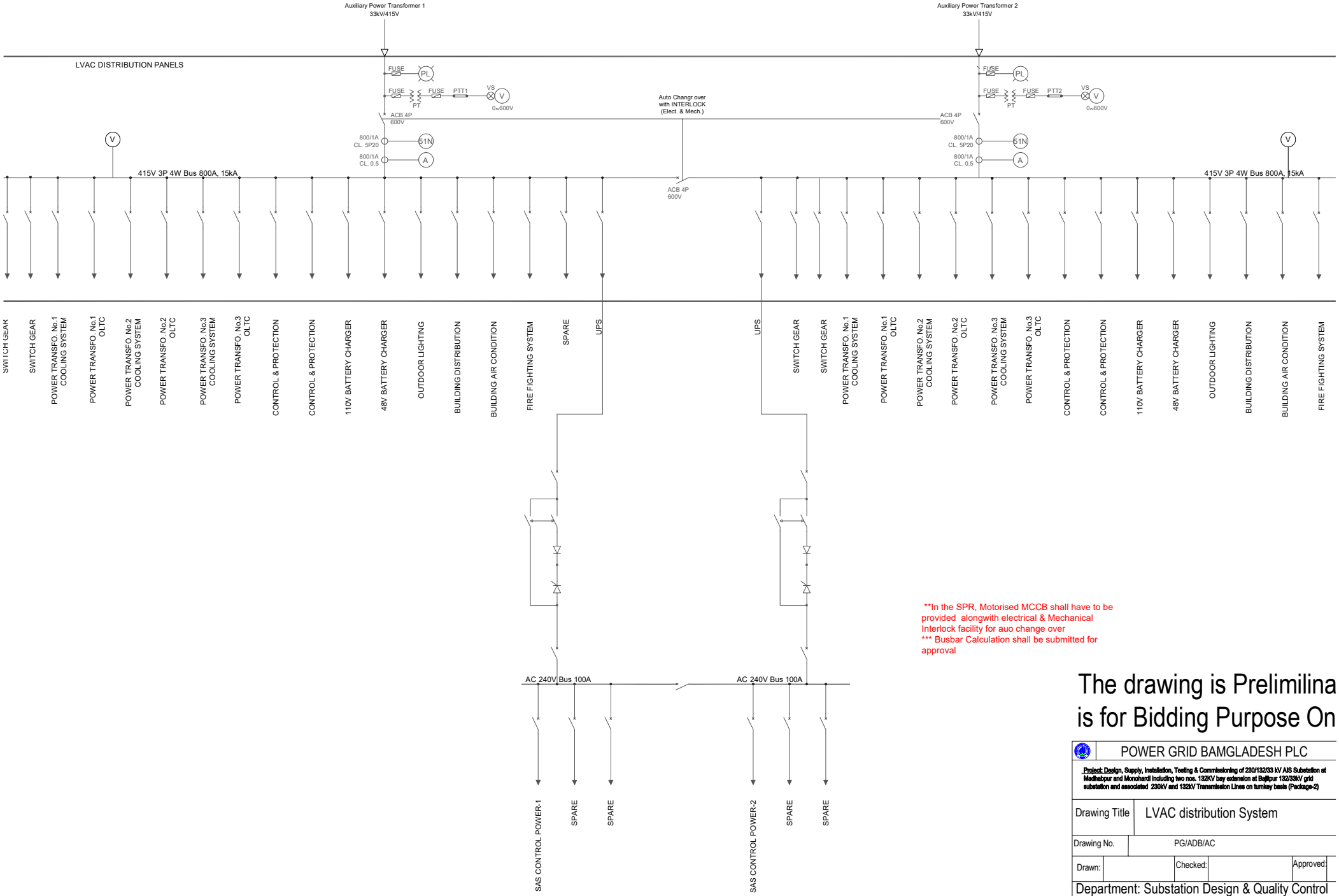
POWER GRID BANGLADESH PLC

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Moncharli including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing Title	48V DC Distribution scheme
Drawing No.	PG/ADB/DC_48V
Drawn:	Checked: Approved:

Department: Substation Design & Quality Control

LV AC

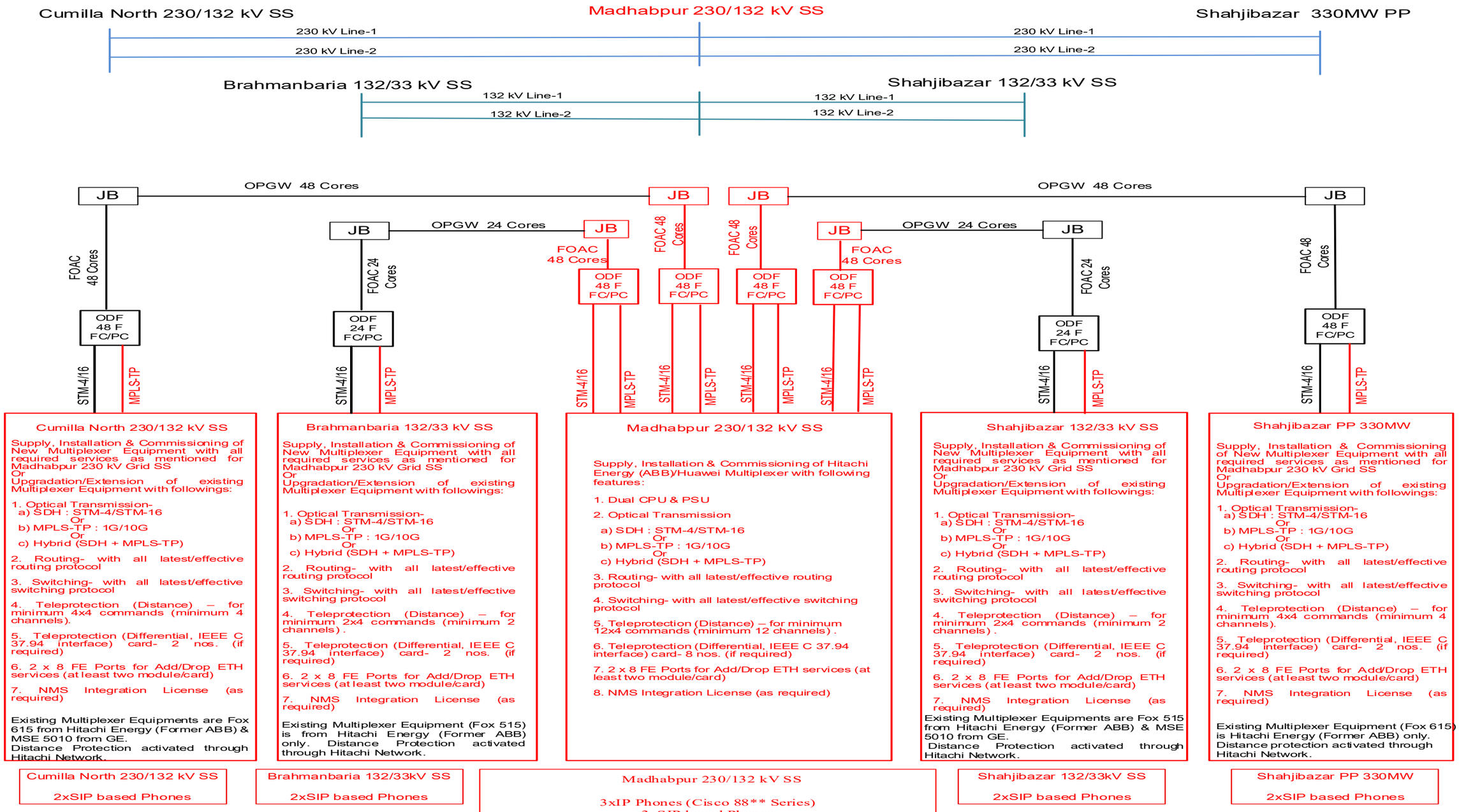


**In the SPR, Motorised MCCB shall have to be provided alongwith electrical & Mechanical Interlock facility for auo change over
*** Busbar Calculation shall be submitted for approval

The drawing is Prelimilina is for Bidding Purpose On

POWER GRID BAMGLADESH PLC			
Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33KV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)			
Drawing Title	LVAC distribution System		
Drawing No.	PG/ADB/AC		
Drawn:	Checked:	Approved:	
Department: Substation Design & Quality Control			

Proposed Optical Communication Scheme for Madhabpur 230/132 kV SS



N. B. :

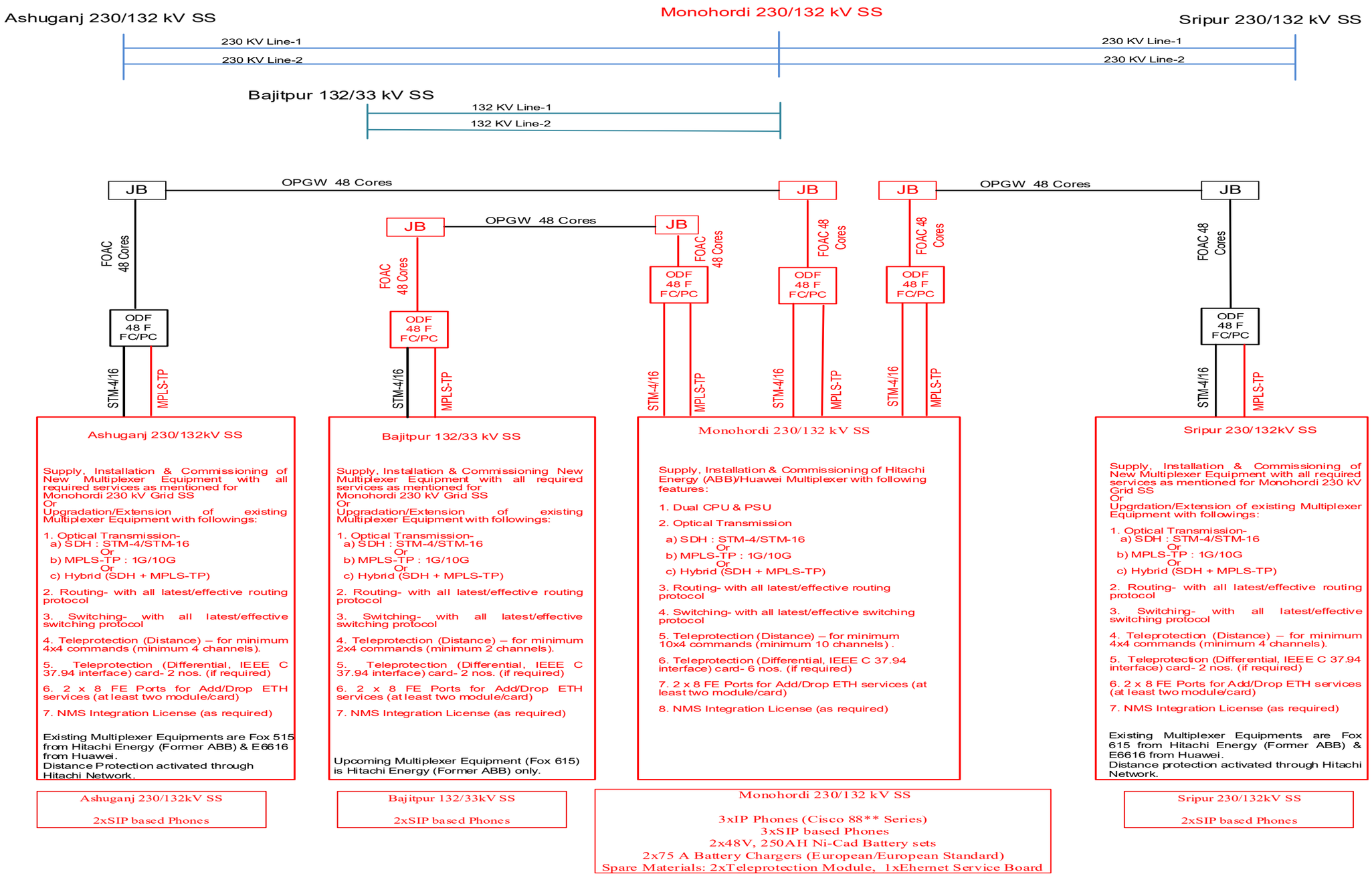
1. All RED are scope of this project.
2. OPGW of LILO portion/portions (not shown in drawing) is/are also scope of this project.
3. In case of upgradation of the Multiplexer all the existing services shall be considered.
4. All Testing & Commissioning work shall be performed by OEM/OEM certified Engineer.
5. If Optical connectivity at one station with others are more than three (03) in that case additional transmission module shall be provided.
6. If different multiplexer equipment rather than existing is proposed in the remote stations having power consumption more than 10 amps then additional 48 volt battery chargers & battery sets shall be provided within the project scope.

Tender purpose only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing no: PG/ADB/OPT_Madhabpur

Proposed Optical Communication Scheme for Monohordi 230/132 KV SS



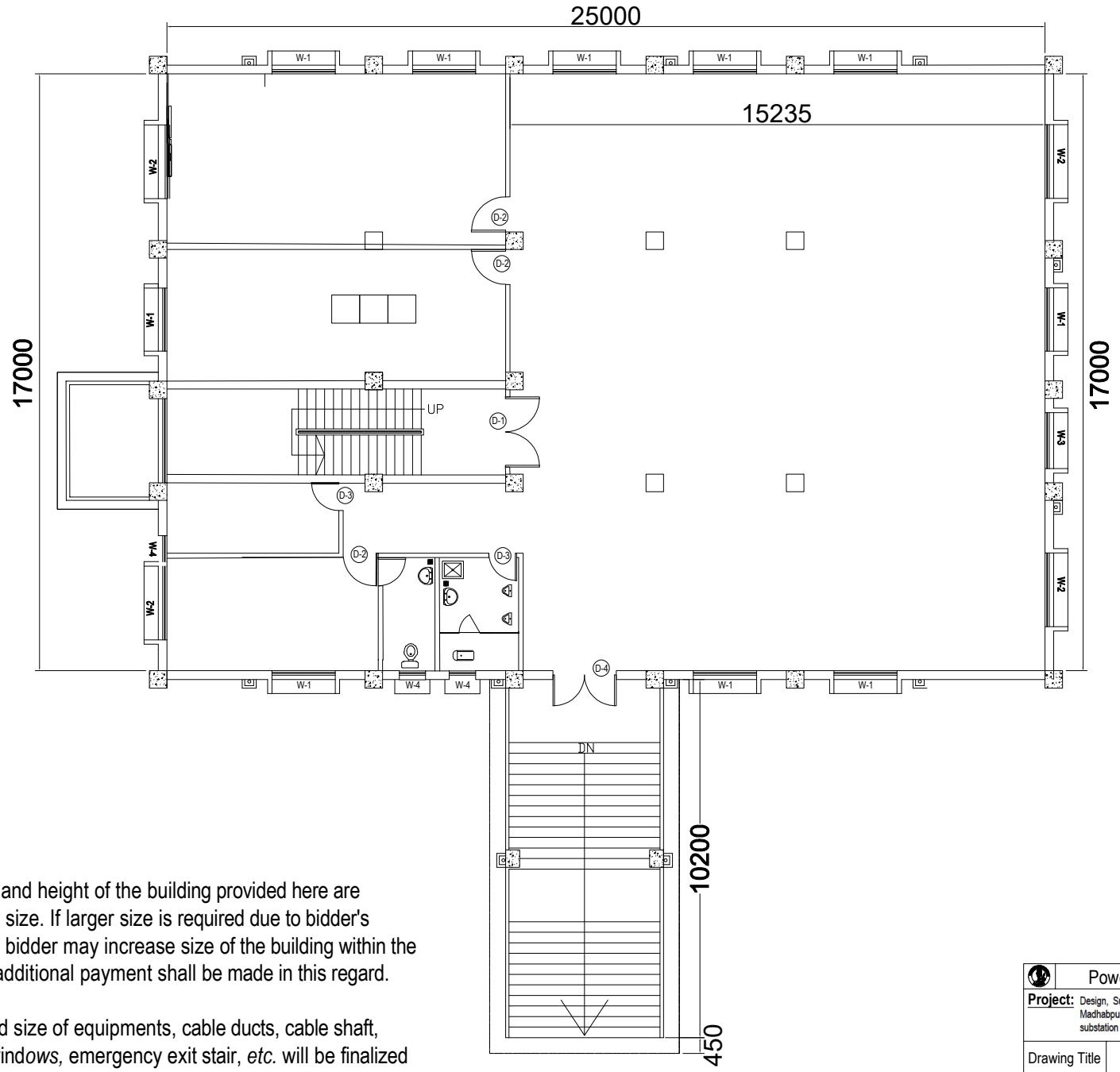
N.B.:

1. All RED are scope of this project.
2. OPGW of LILO portion/portions (not shown in drawing) is/are also scope of this project.
3. In case of upgradation of the Multiplexer all the existing services shall be considered.
4. All Testing & Commissioning work shall be performed by OEM/OEM certified Engineer.
5. If Optical connectivity at one station with others are more than three (03) in that case additional transmission module shall be provided.
6. If different multiplexer equipment rather than existing is proposed in the remote stations having power consumption more than 10 amps then additional 48 volt battery chargers & battery sets shall be provided within the project scope.

Tender purpose only

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

Drawing no: PG/ADB/OPT_Monohardi



Note:

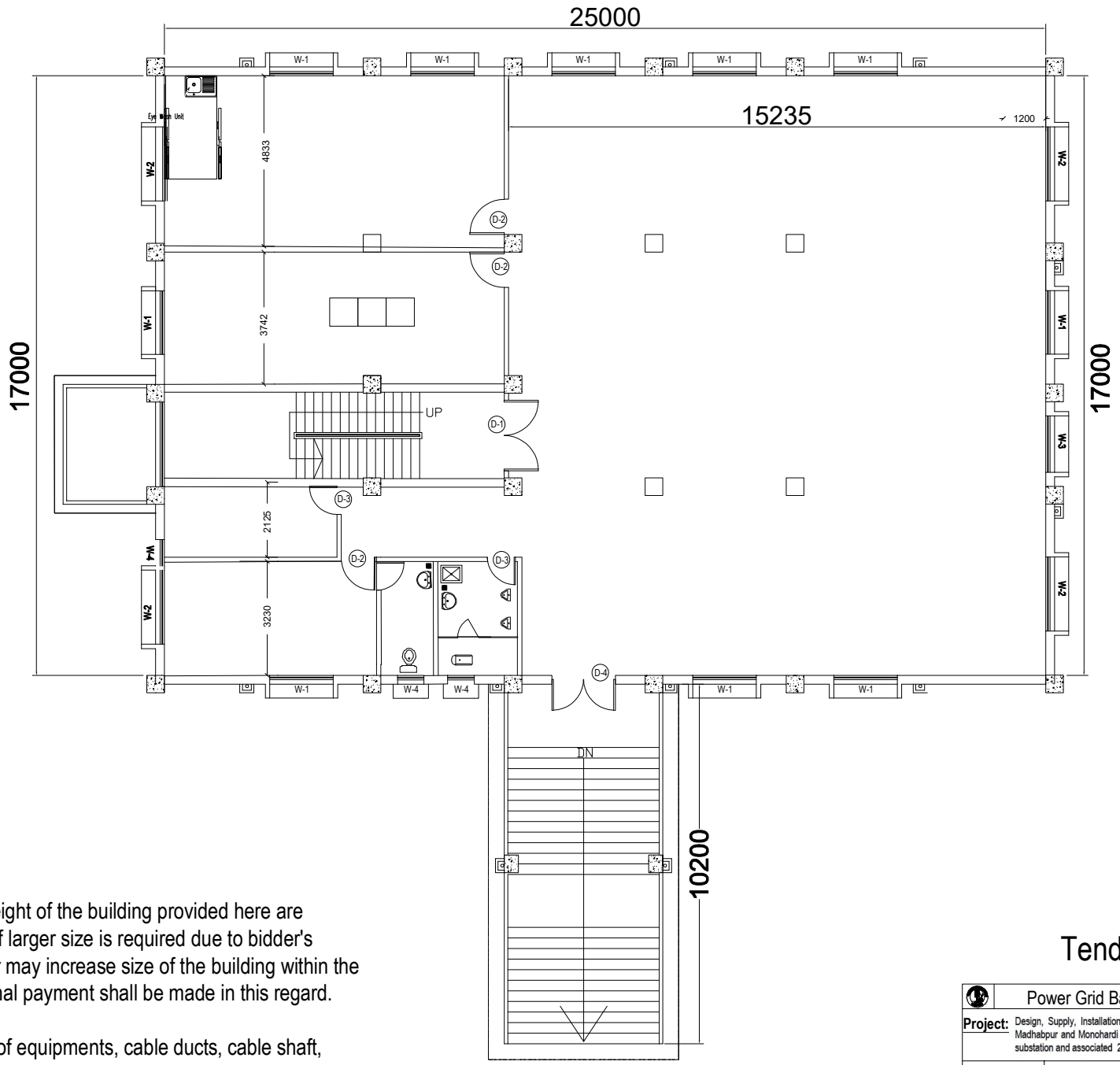
1) Floor area and height of the building provided here are minimum required size. If larger size is required due to bidder's specifications; the bidder may increase size of the building within the quoted price. No additional payment shall be made in this regard.

2) Position and size of equipments, cable ducts, cable shaft, columns, doors, wind*ows,* emergency exit stair, *etc.* will be finalized during detail design.

Control Room Building_Ground Floor

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Main Control Building _Ground Floor Plan View
Drawing No.	PG/ADB/MCRP-1
Drawn:	Checked: Approved:
Department: Substation Design & Quality Control	



Note:

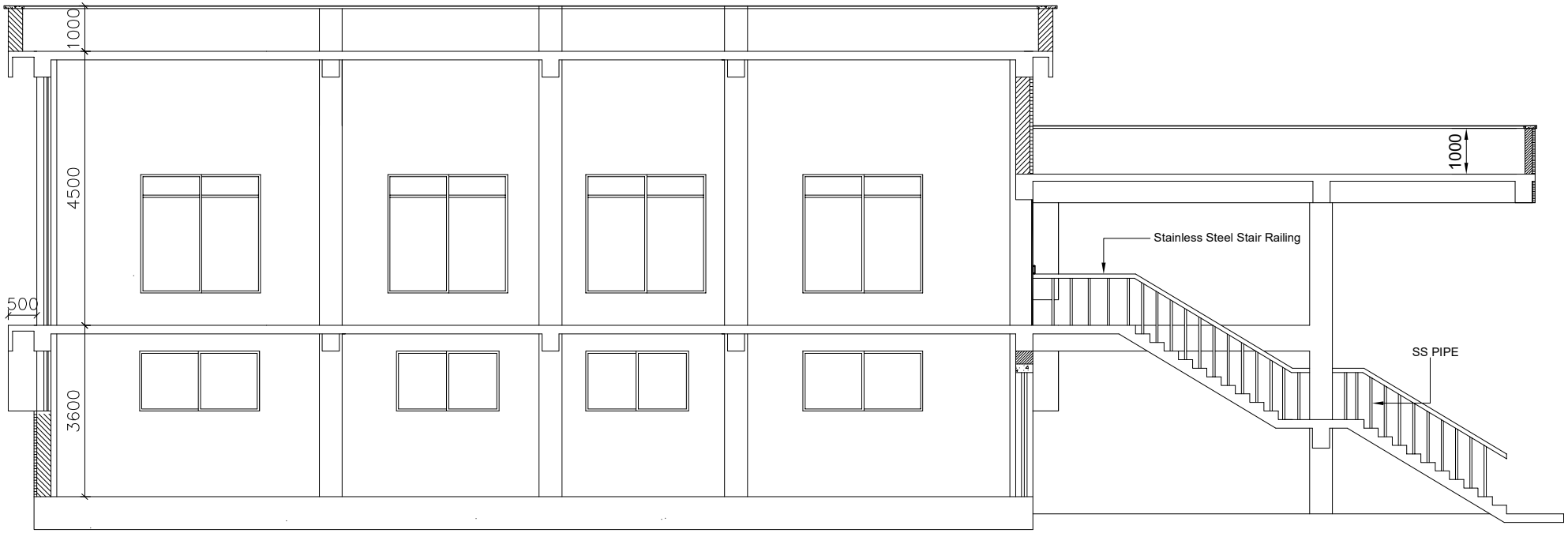
1) Floor area and height of the building provided here are minimum required size. If larger size is required due to bidder's specifications; the bidder may increase size of the building within the quoted price. No additional payment shall be made in this regard.

2) Position and size of equipments, cable ducts, cable shaft, columns, doors, wind*ows,* emergency exit stair, *etc.* will be finalized during detail design.

Control Room Building_First Floor

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Main Control Building _First Floor Plan View
Drawing No.	PG/ADB/MCRP-2
Drawn:	Checked: Approved:
Department: Substation Design & Quality Control	

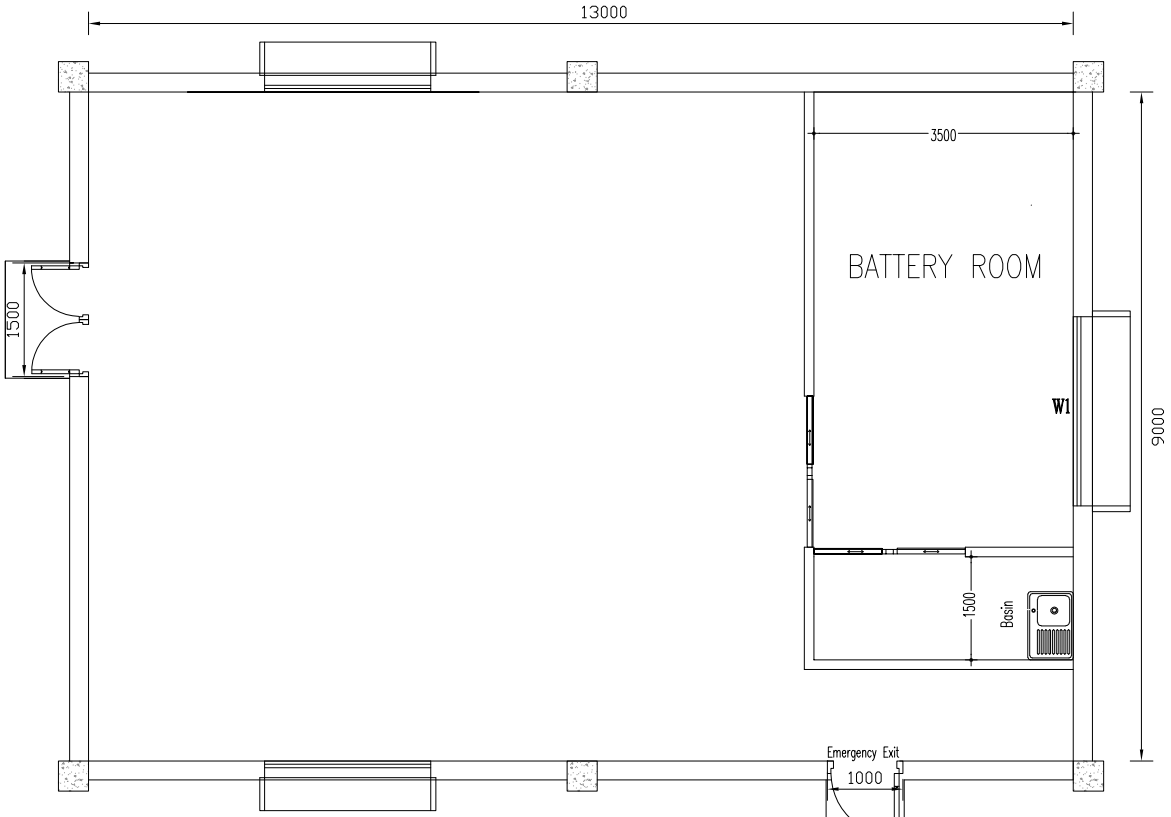


SECTION VIEW

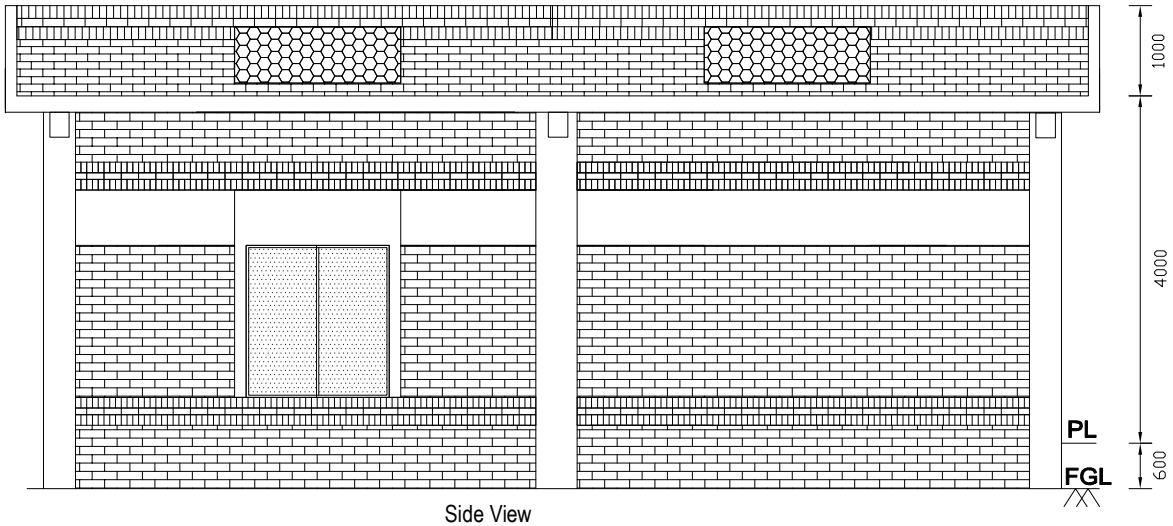
Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Main Control Room Elevation
Drawing No.	PG/ADB/MCRE
Drawn:	Checked: Approved:

All dimensions are in mm.



GROUND FLOOR PLAN of 132KV SPR WITH BATTERY ROOM



Side View

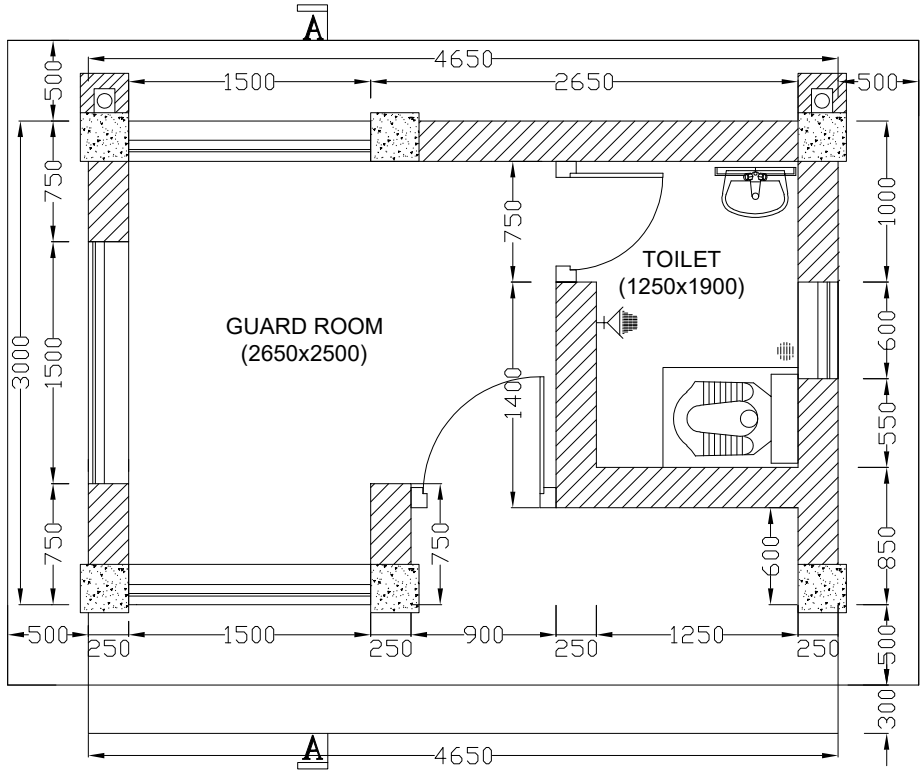
Note:

1) Floor area and height of the building provided here are minimum required size. If larger size is required due to bidder's specifications (including future); the bidder may increase size of the building within the quoted price. No additional payment shall be made in this regard.

2) Position and size of panels, equipments, ducts, columns, doors, windows, emergency exit *etc.* will be finalized during detail design.

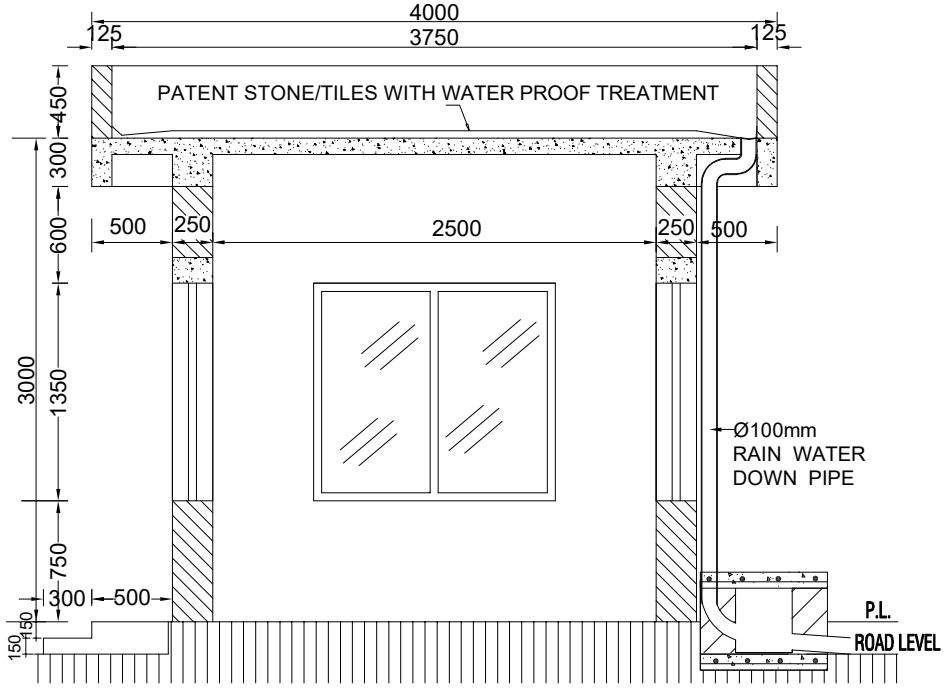
Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	FLOOR PLAN AND SECTION OF 132KV SPR
Drawing No.	PG/ADB/SPR_132
Drawn:	Checked: Approved:

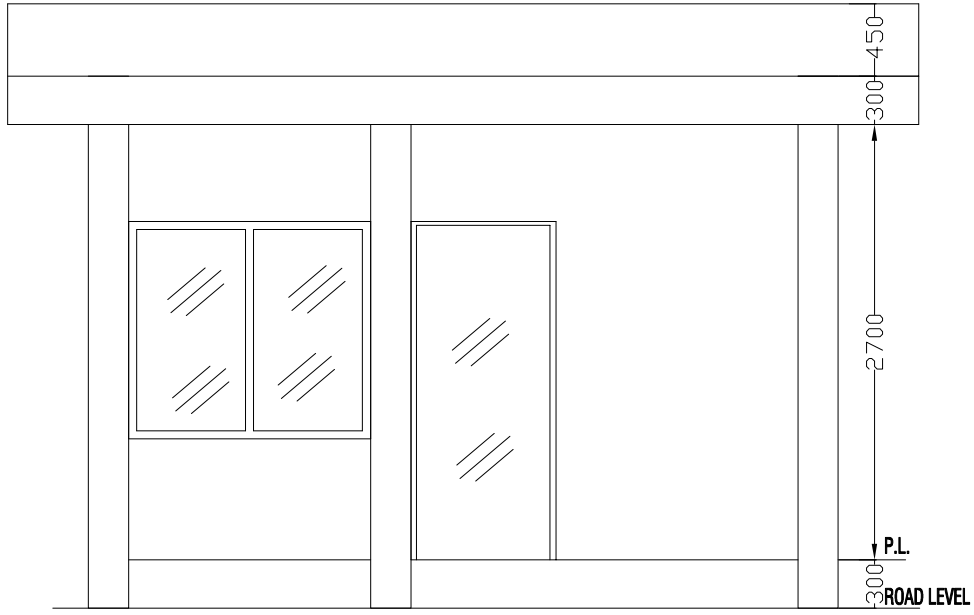


POCKET GATE

PLAN OF GUARD HOUSE



SECTION : A-A



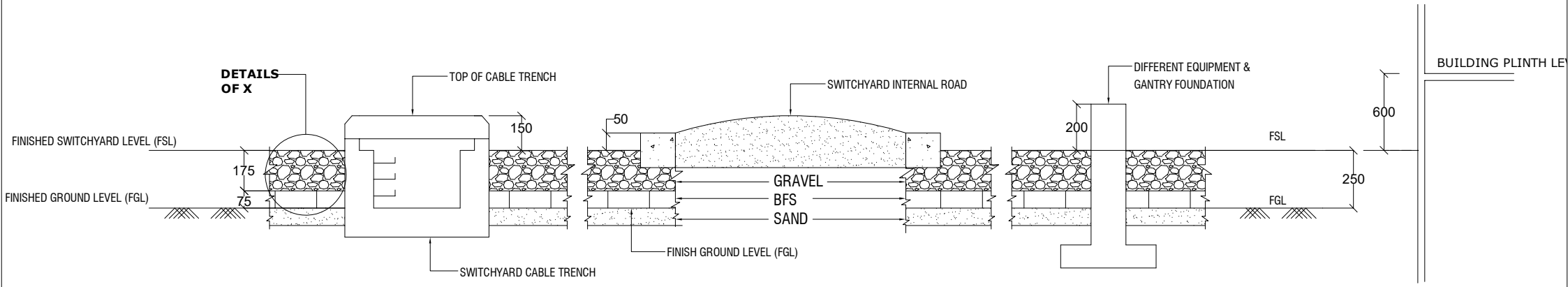
ROAD SIDE ELEVATION

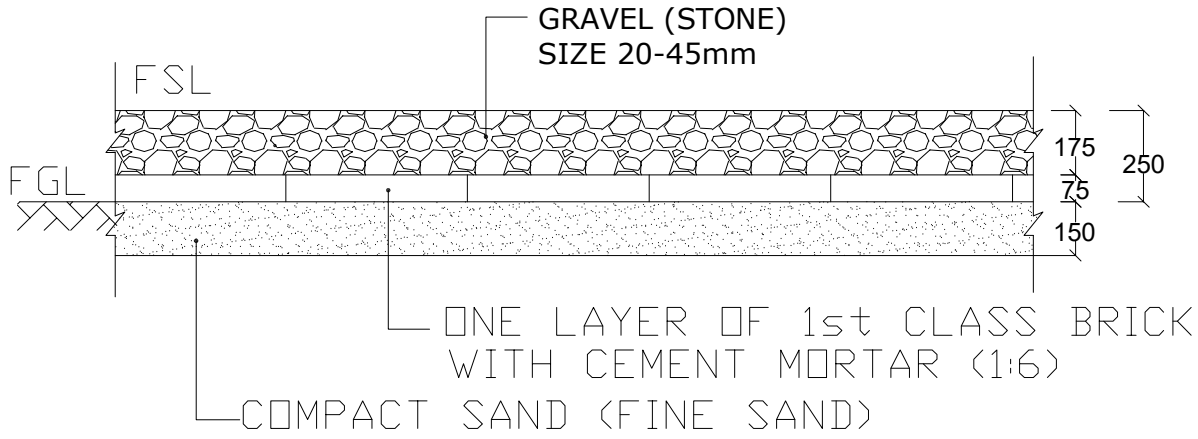
NOTES:

1. DETAILS OF ARCHITECTURAL, STRUCTURAL & FOUNDATION DRAWING SHALL BE SUBMITTED FOR APPROVAL.
2. WATER SUPPLY SYSTEM, TOILET & OTHER SANITARY FITTINGS SHALL BE PROVIDED.
3. ROOF SHALL BE WATER PROOFED WITH PATENT STONE/TILES.
4. RAIN WATER DOWN PIPE & BUILDING DRAINAGE SYSTEM SHALL BE TAKE INTO CONSIDER PRIOR TO SLAB CASTING.
5. POWER CONNECTION LAYOUT SHALL BE APPROVED BEFORE WORK.

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Guard House
Drawing No.	PG/ADB/GH
Drawn:	Checked: Approved:





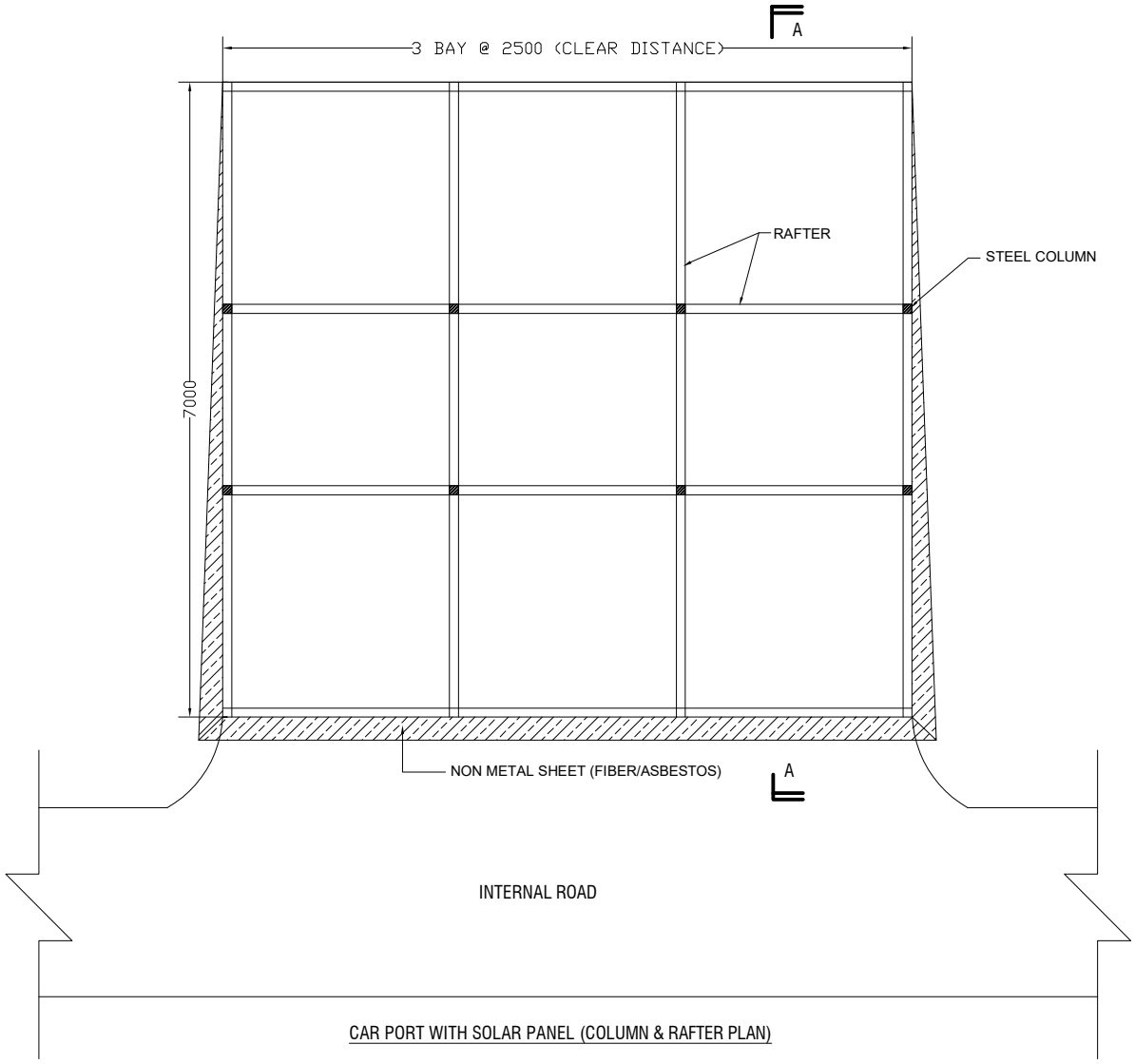
DETAIL OF X

NOTE:

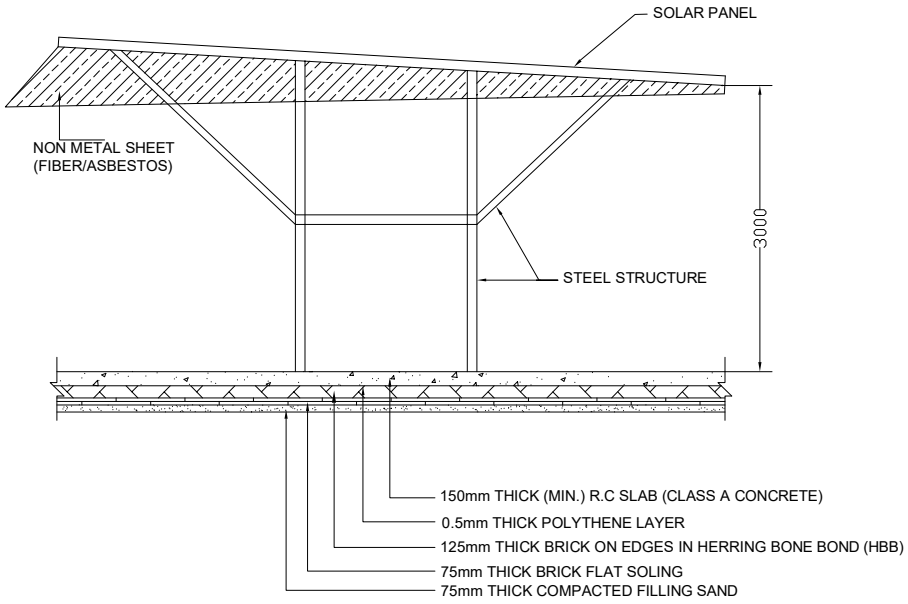
After determination of Finished Ground Level (FGL) with respect to MSL/PWD, the contractor should prepare and submit the relative RLs of all the structures for approval for each site.

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Switchyard Surface Level
Drawing No.	PG/ADB/SSL
Drawn:	Checked: Approved:



CAR PORT WITH SOLAR PANEL (COLUMN & RAFTER PLAN)

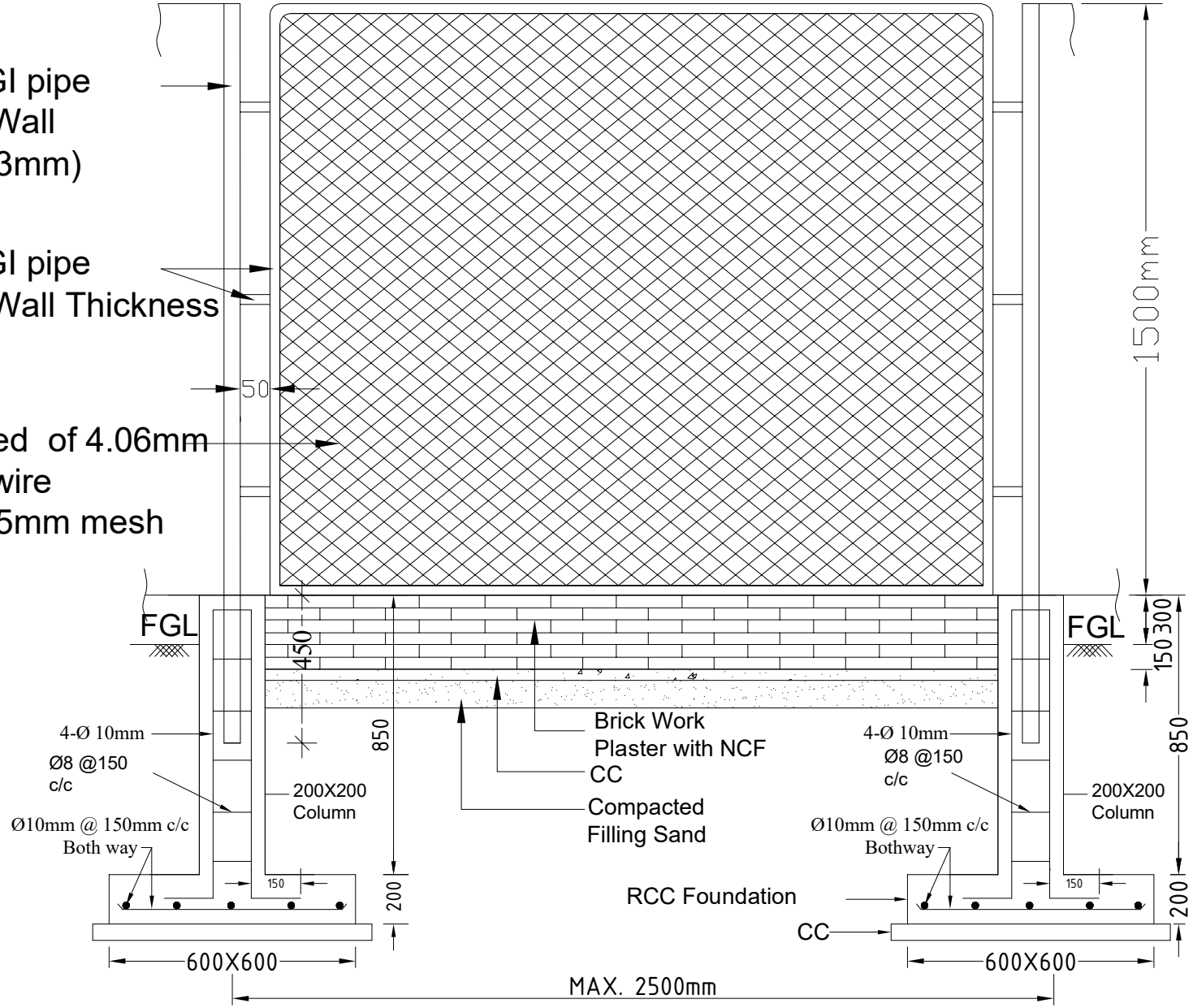


SECTION A-A

NOTES:
1. DETAILS OF ARCHITECTURAL, STRUCTURAL & FOUNDATION DRAWING SHALL BE SUBMITTED FOR APPROVAL.
2. SOLAR PANEL SHALL BE PLACED ON ROOF.
3. TILT ANGEL AND AZIMUTH ANGEL SHALL BE FINALIZED DURING DETAILED DESIGN.

Tender Drawing

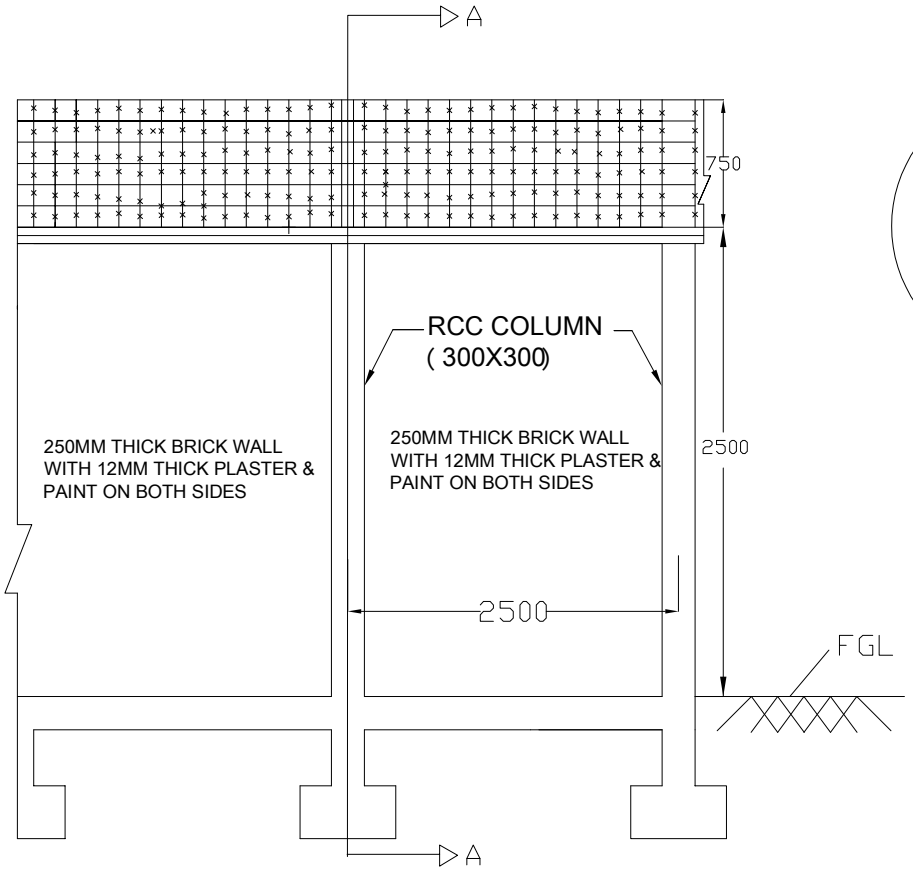
Power Grid Bangladesh PLC	
Project	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Car Port with Solar Panel (For Three Bays)
Drawing No.	PG/ADB/CAR
Drawn:	Checked: Approved:



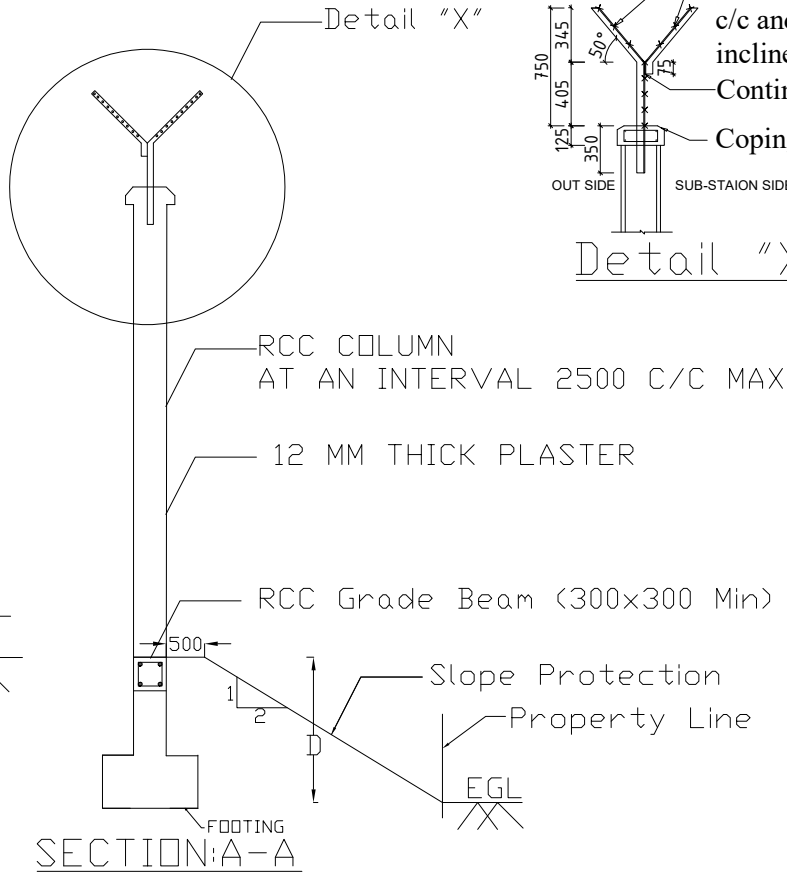
Typical Section of Chain Linked Fencing

Tender Drawing

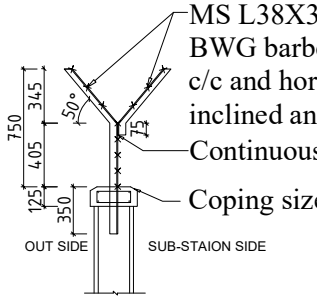
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Typical Section of Chain linked fencing
Drawing No.	PG/ADB/Fence
Drawn:	Checked: Approved:



FRONT ELEVATION



SECTION:A-A



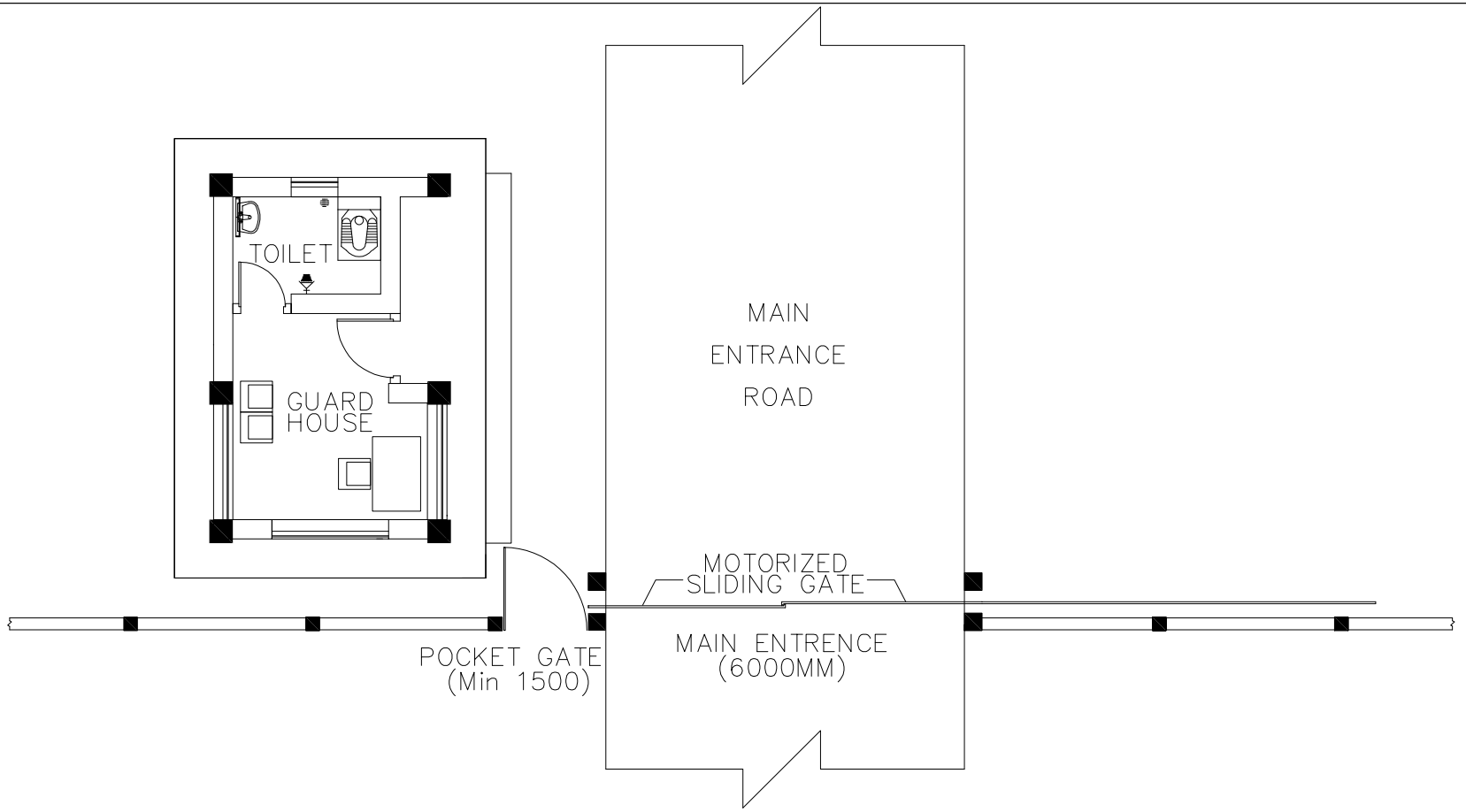
Detail "X"

NOTE:

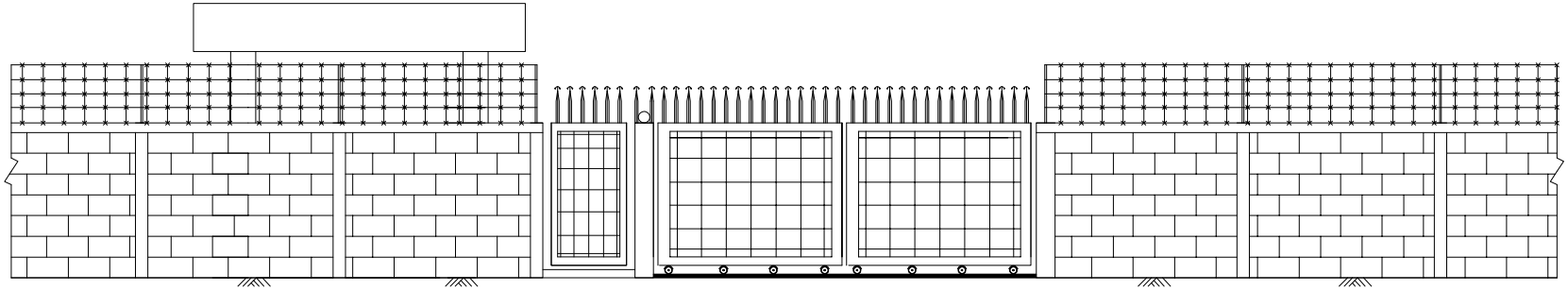
1) "EGL" means Existing Ground level
2) "FGL" means Finished Ground level
3) ALL DIMENSIONS ARE IN MM
4) 'D'=Depth of Earth Filling for Land Development
5) Expansion Joints shall have to be provided at maximum 25m Interval.

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Boundary wall without retaining wall
Drawing No.	PG/ADB/BW
Drawn:	Checked: Approved:



PLAN VIEW



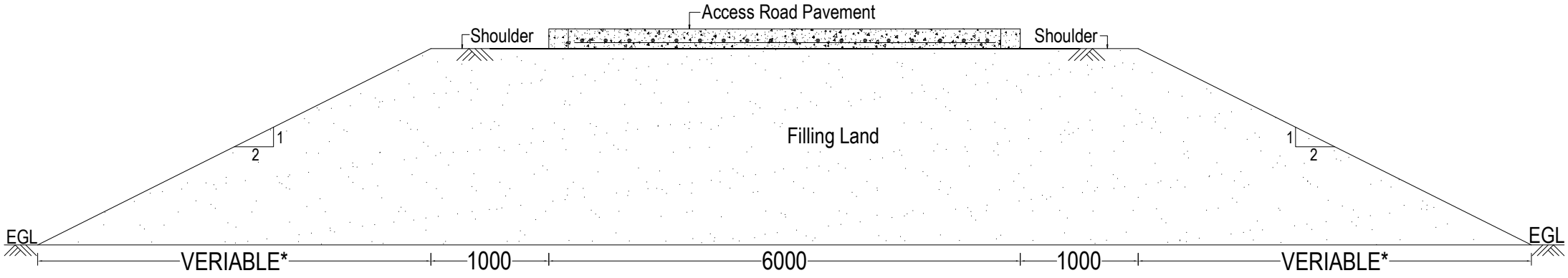
FRONT VIEW

ENTRANCE GATE

NOTE: Gate design shall be finalized during design stage.

Tender Drawing

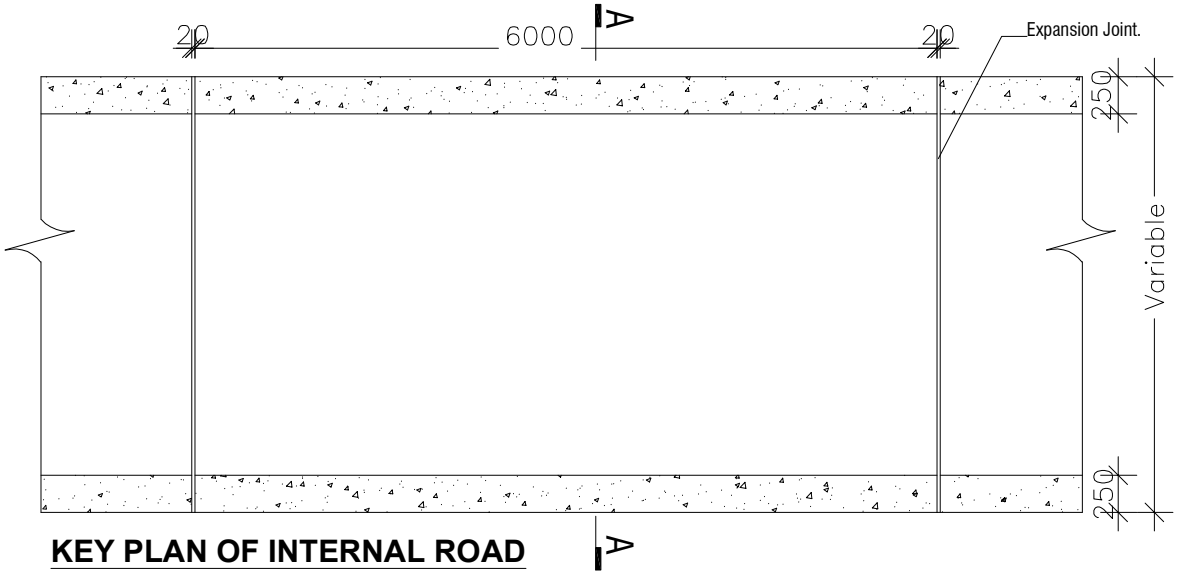
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Main Entrance Gate
Drawing No.	PG/ADB/GATE
Drawn:	Checked: Approved:



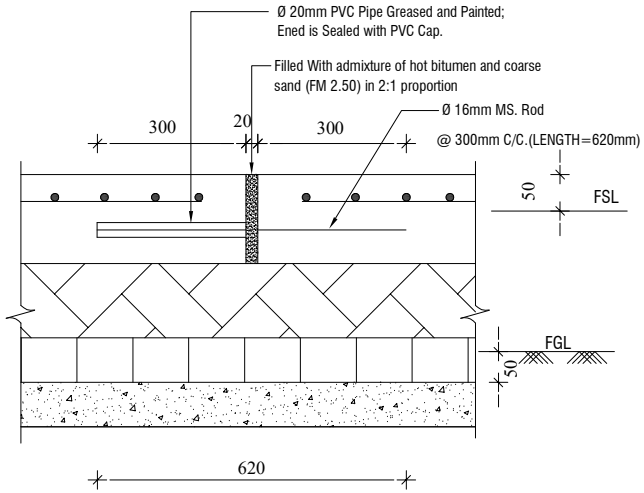
TYPICAL SCHEMATIC DIAGRAM FOR APPROACH ROAD

Tender Drawing

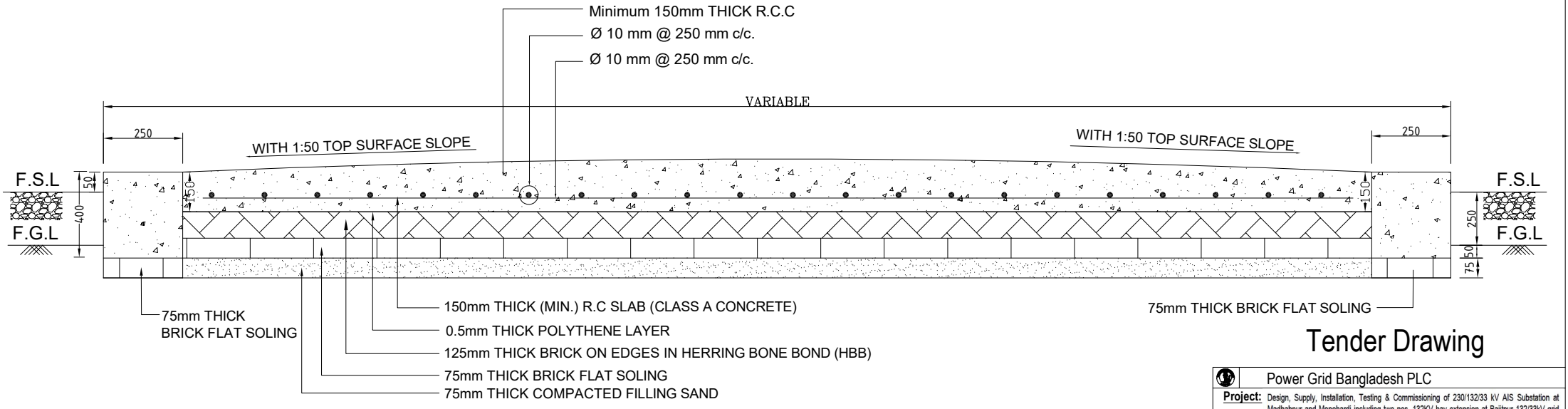
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Approach Road
Drawing No.	PG/ADB/AR
Drawn:	Checked: Approved:



KEY PLAN OF INTERNAL ROAD
(SCALE - NTS)



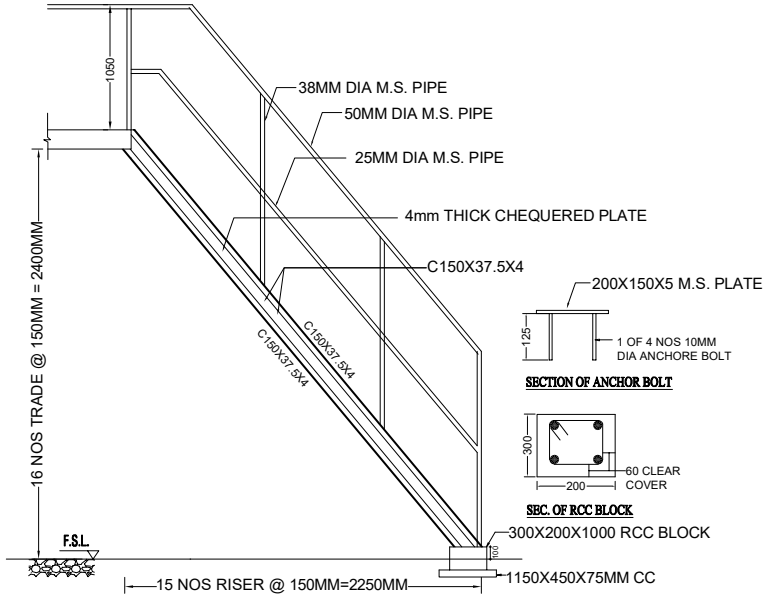
DETAIL OF EXPANSION JOINT
(SCALE - NTS)



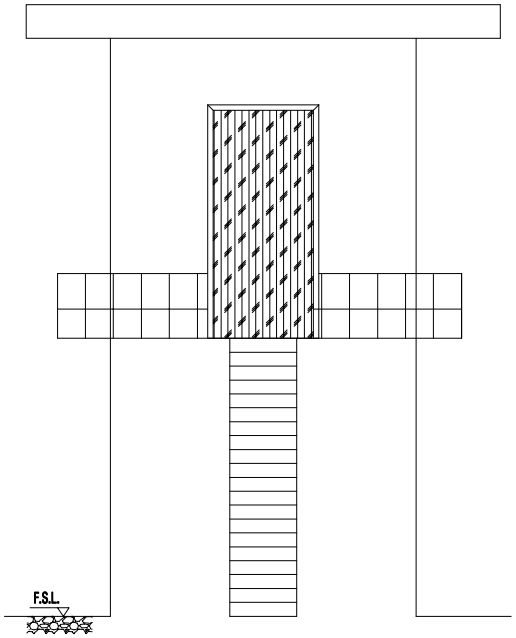
ROAD CROSS SECTION : A-A
(SCALE - NTS)

Tender Drawing

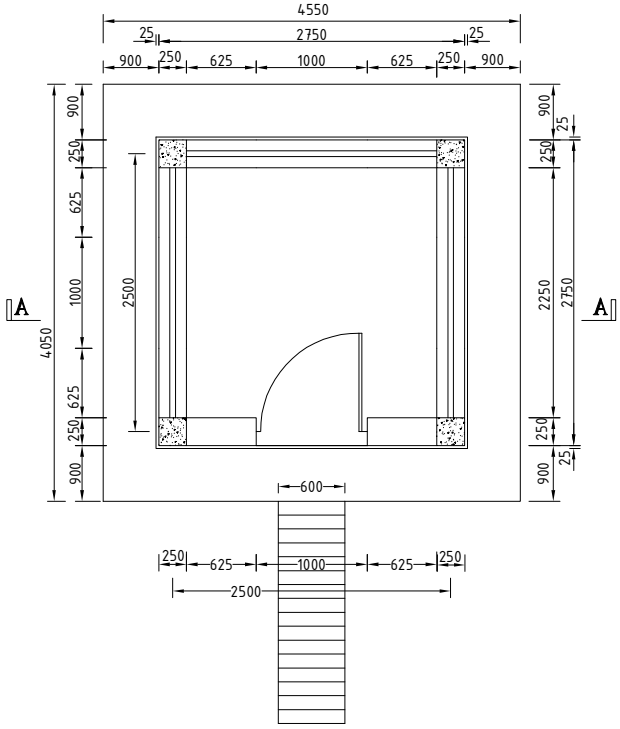
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Typical Road sections
Drawing No.	PG/ADB/TRS
Drawn:	Checked: Approved:



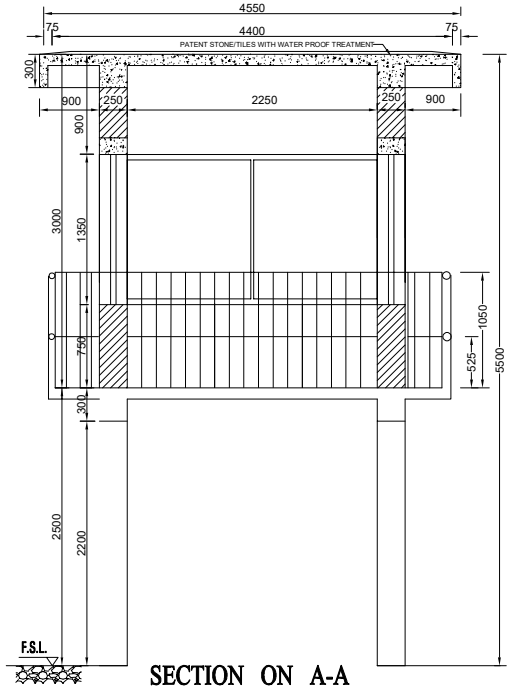
DETAILS OF STAIR



FRONT ELEVATION



PLAN OF SENTRY POST



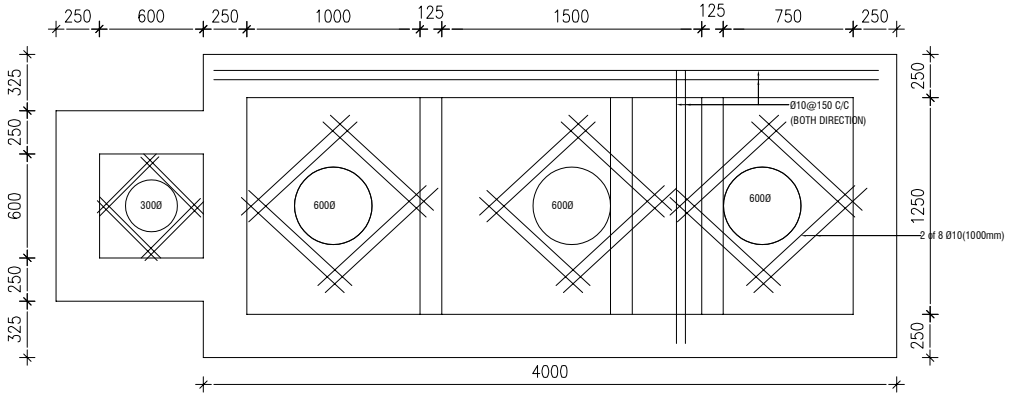
SECTION ON A-A

NOTES:

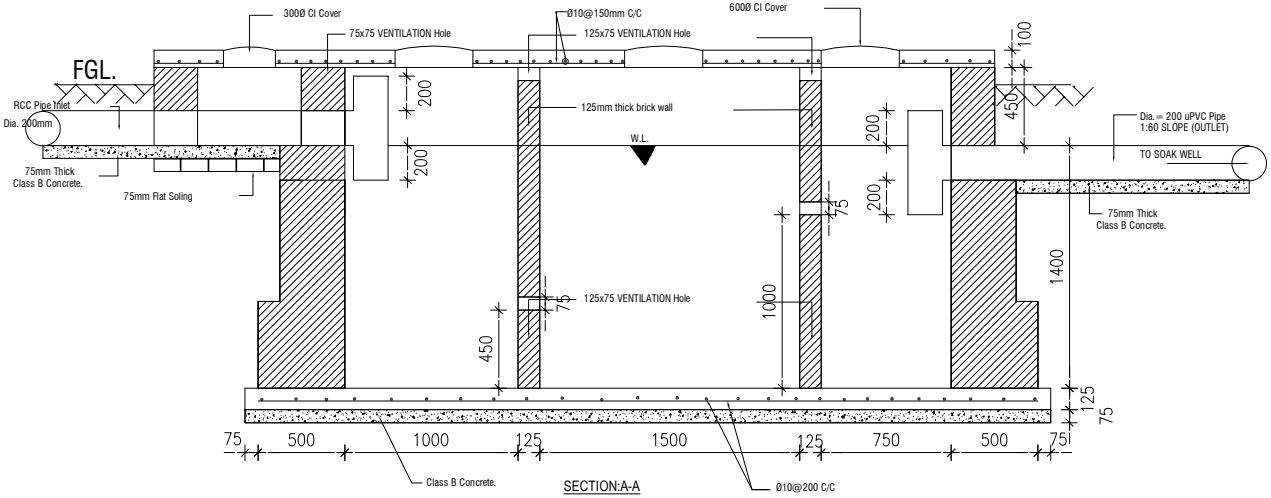
1. DETAILS OF ARCHITECTURAL, STRUCTURAL & FOUNDATION DRAWING & LADDER DETAILS SHALL BE SUBMITTED FOR APPROVAL.
2. ROOF SHALL BE WATER PROOFED WITH WITH PATENT STONE/TILES.
3. RAIN WATER DOWN PIPE & BUILDING DRAINAGE SYSTEM SHALL BE TAKE INTO CONSIDER PRIOR TO SLAB CASTING.
4. POWER CONNECTION LAYOUT SHALL BE APPROVED BEFOR WORK.
5. ALL EXPOSED STEEL SHALL BE GALVANIZED PAINT.

Tender Drawing

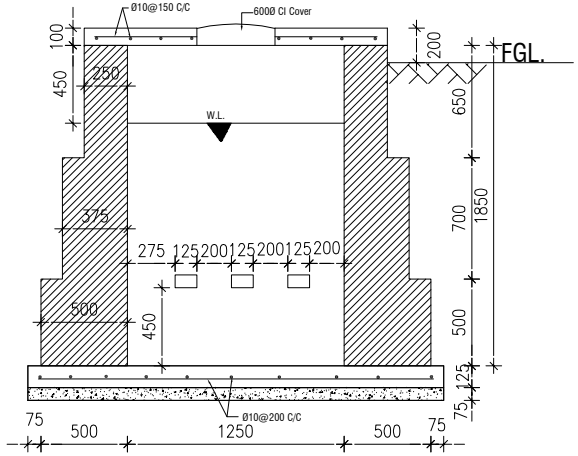
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Sentry Post
Drawing No.	PG/ADB/SEP
Drawn:	Checked: Approved:



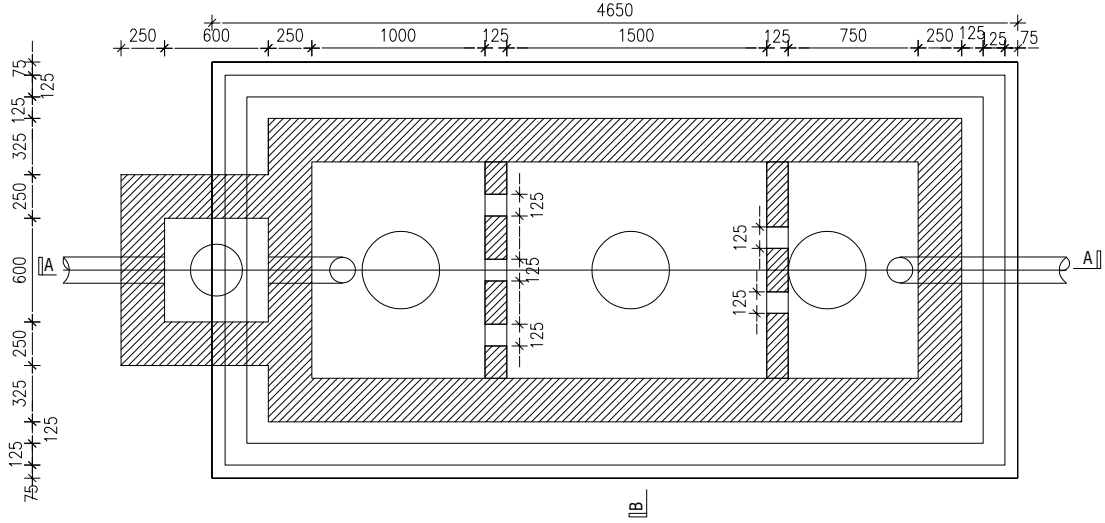
TOP SLAB REINFORCEMENT OF SEPTIC TANK



SECTION:A-A



SECTION:B-B



PLAN OF SEPTIC TANK.

NOTES:

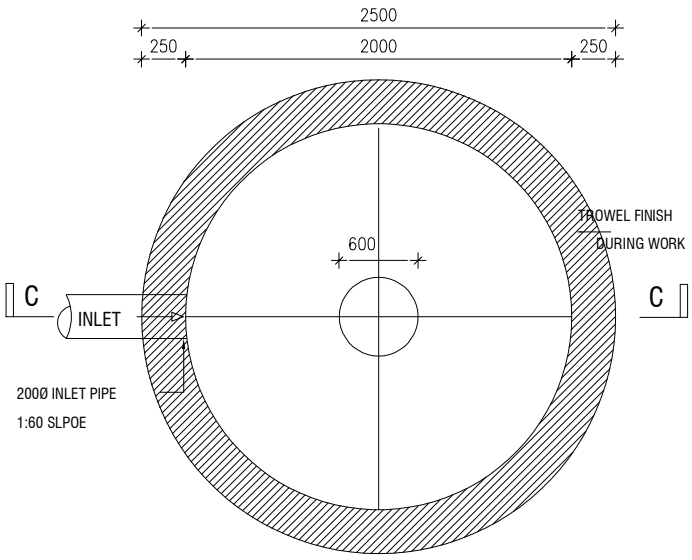
1. TYPE OF COVER FOR ALL INSPECTION HOLES IS C.I.
2. SIZE OF THE HOLE INSIDE BRICK HOLE INSIDE BRICK WALL FOR SEPTIC TANK IS 125X75 mm2.
3. R.C.C. WORK AS PER APPROVED MIX. DESIGN.
4. MINIMUM YIELD STRENGTH OF REBAR IS 415 N/ mm2.
5. MORTAR MIXING PROPORTION IS 1:4
6. PLASTER MIXING PROPORTION IS 1:3.
7. THE INTERIOR OF ALL SEPTIC TANKS AND MANHOLES CARRYING FOUL SEWAGE SHALL RECEIVE TWO COATS OF BITUMASTIC PAINT.
8. ALL SPECIFICATION WILL BE FOLLOWED AS SPECIFIED IN THE CONTRACT.
9. ALL EXTERIOR BRICK WORK OF SP & SW SHALL BE FURNISHED WITH NCF.
10. MINIMUM CLEAR COVER OF THE REBAR (BELOW GROUND LEVEL) IS 60mm.
11. SEPTIC TANK SHOULD BE LOCATED ADEQUATE DISTANCE FROM CONTROL BUILDING.
12. ALL DIMENSIONS ARE IN mm WHERE NOT STATED.

Tender Drawing

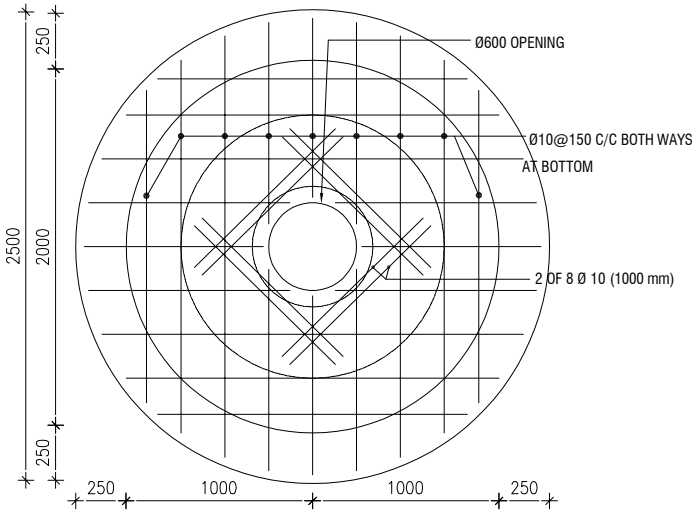
Power Grid Bangladesh PLC

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

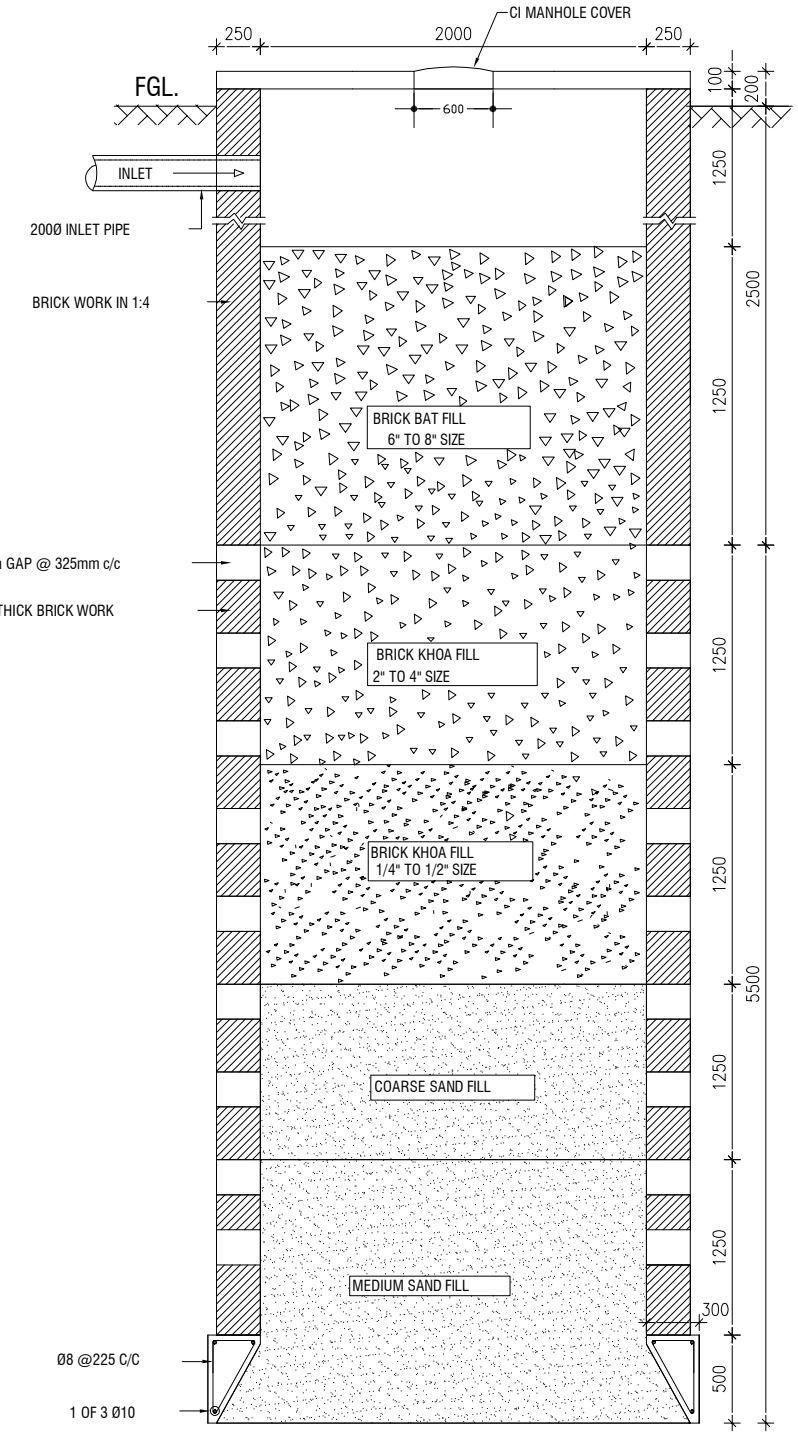
Drawing Title	Septik Tank				
Drawing No.	PG/ADB/ST				
Drawn:		Checked:		Approved:	



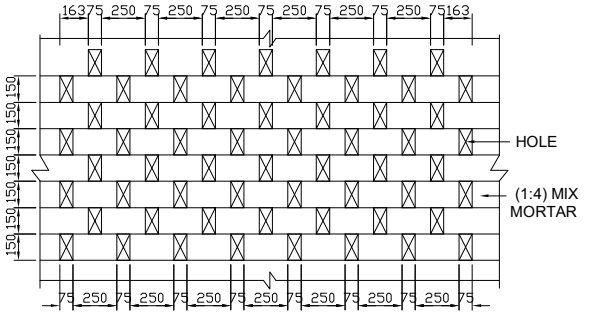
PLAN OF SOAK WELL (SW)



SLAB OF SW
REINFORCEMENT PLAN OF TOP



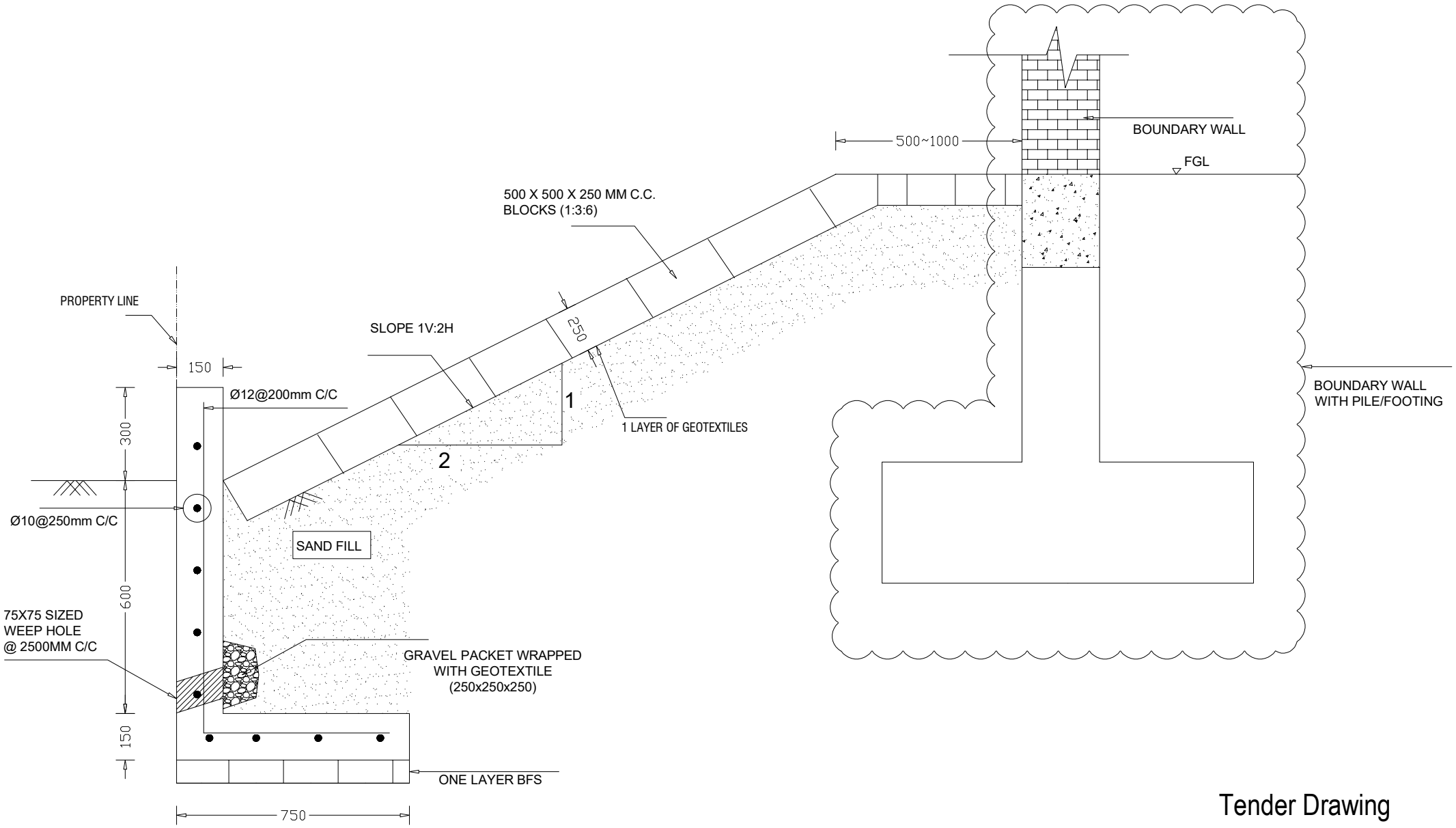
SECTION ON C - C



PART VIEW OF WALL WITH HOLE

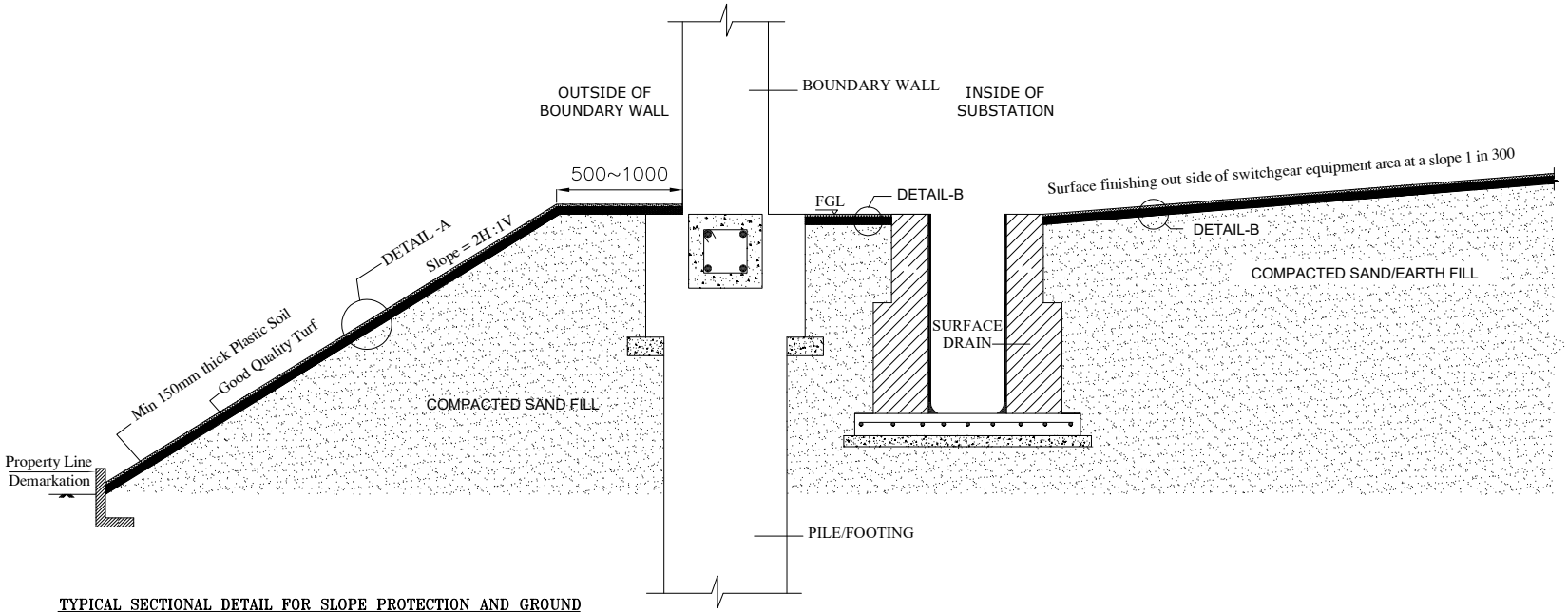
Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Soak Well for Septik Tank
Drawing No.	PG/ADB/SW
Drawn:	Checked: Approved:

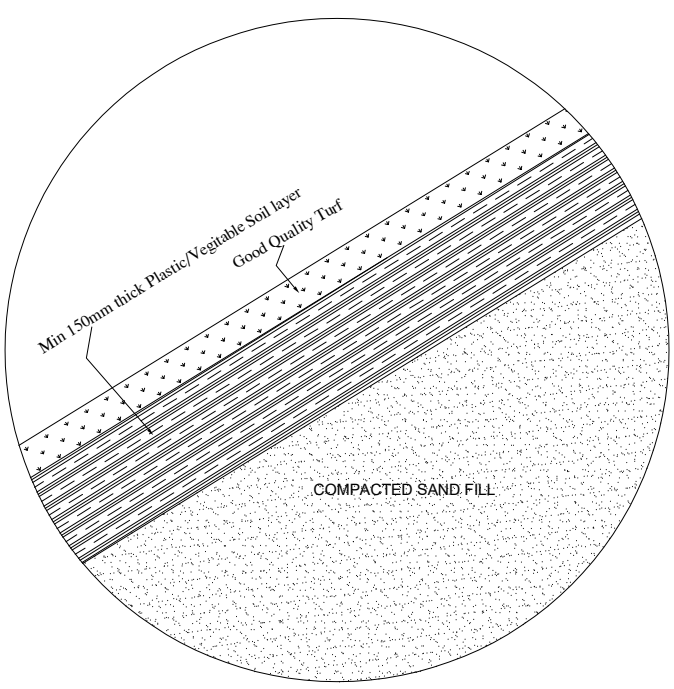


Tender Drawing

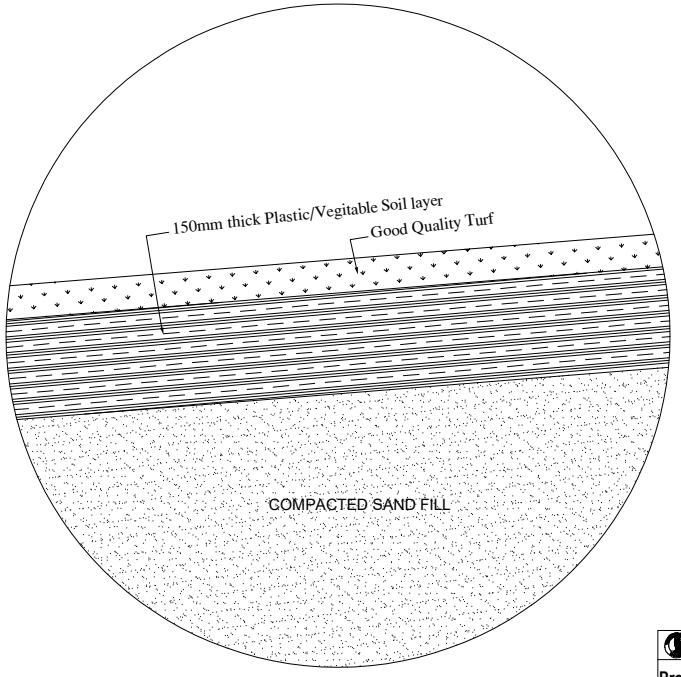
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Slpoe (1V:2H) protection with CC blocks
Drawing No.	PG/ADB/SLP (1)
Drawn:	Checked: Approved:



TYPICAL SECTIONAL DETAIL FOR SLOPE PROTECTION AND GROUND SURFACE FINISHING AROUND THE SURFACE DRAIN



DETAIL-A



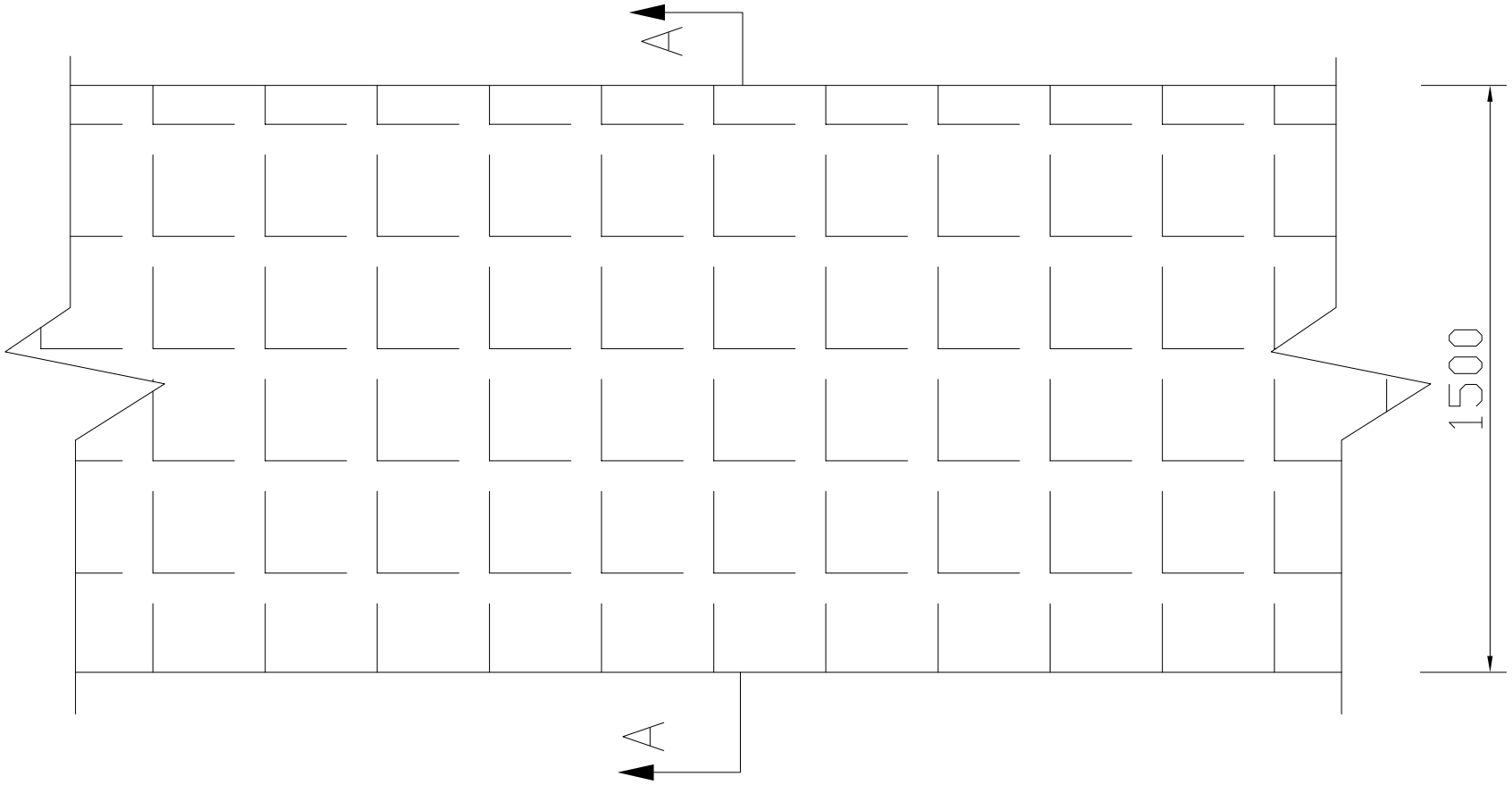
DETAIL-B

NOTE :

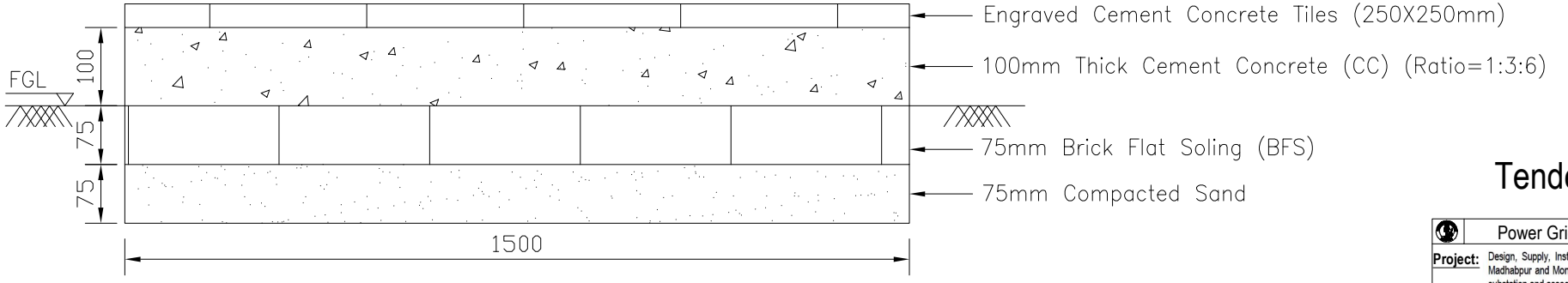
The substation plot, outside of the designated switchgear equipment areas, shall be turfed. Turf shall be of good quality, free from weeds and impurities. Samples of the turf which is proposed to use shall have to be approved by the Engineer. The turfs shall be laid to even surfaces on a bed of vegetable soil, which shall be raked and consolidated to provide a suitable bed.

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Slpoe (1V:2H) protection with turfing
Drawing No.	PG/ADB/SLP (2)
Drawn:	Checked: Approved:



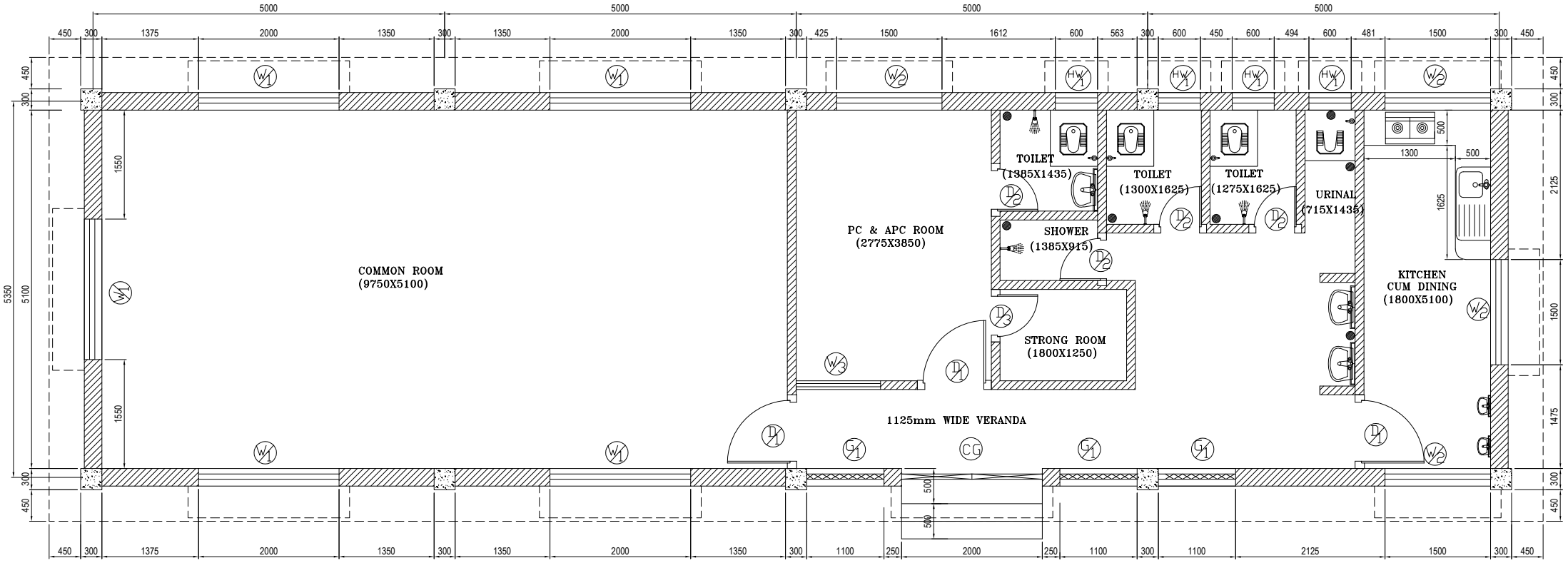
WALKWAY ROAD PLAN



SECTION: A–A

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Walk Way
Drawing No.	PG/ADB/WW
Drawn:	Checked: Approved:



PLAN OF ANSAR BARRACK

FRONT

LEGEND

D = DOOR
W = WINDOW
HW = HIGH WINDOW
CG = COLLAPSIBLE GATE
G = VERANDA GRIL

DOOR SCHEDULE

S.L.	NO.	SIZE		MATERIAL
		WIDTH	HEIGHT	
CG	1	2000	2100	M. STEEL
D /1	3	1050	2100	TIMBER
D /2	4	750	2100	PLASTIC
D /3	1	750	2100	M. STEEL

WINDOW / VERANDA GRIL SCHEDULE

S.L.	NO.	SIZE		MATERIAL
		WIDTH	HEIGHT	
W /1	5	2000	1350	ALUMINIUM
W /2	4	1500	1350	ALUMINIUM
W /3	1	1200	1350	ALUMINIUM
HW /1	4	600	600	ALUMINIUM
G/1	3	1100	1350	MS PLAIN/ FLAT BAR

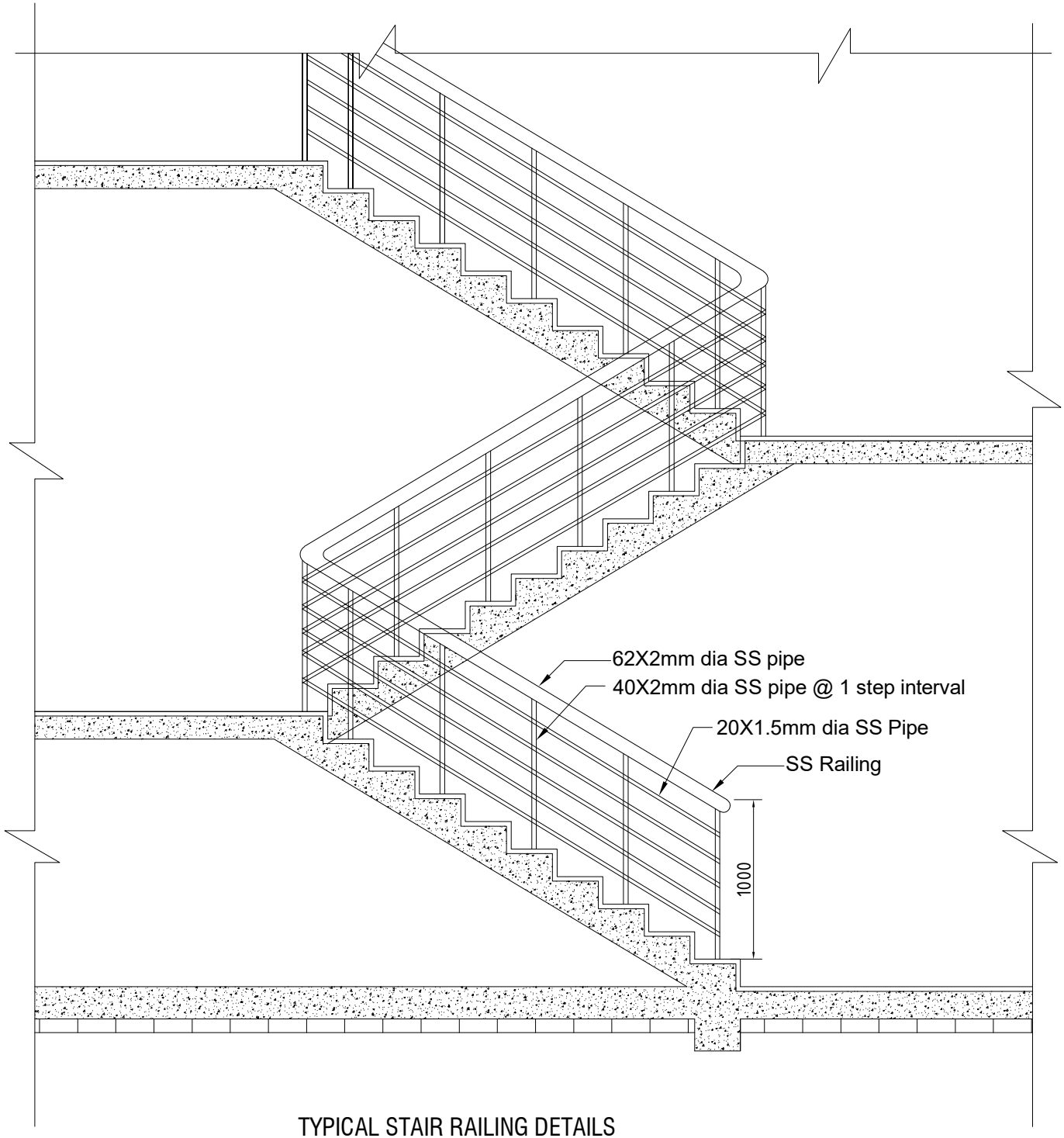
NOTES:
1. ANSAR BARRACK BUILDING SHALL BE RCC FRAME STRUCTURE AND FLOOR HEIGHT SHALL BE 3.0 METER.
2. DETAILS OF ARCHITECTURAL, STRUCTURAL & FOUNDATION DRAWING SHALL BE SUBMITTED FOR APPROVAL.
2. WATER SUPPLY SYSTEM, TOILET & OTHER SANITARY FITTINGS SHALL BE PROVIDED.
3. ROOF SHALL BE WATER PROOFED WITH PATENT STONE/TILES.
4. RAIN WATER DOWN PIPE & BUILDING DRAINAGE SYSTEM SHALL BE TAKE INTO CONSIDER PRIOR TO SLAB CASTING.
5. POWER CONNECTION LAYOUT SHALL BE APPROVED BEFORE WORK.

Tender Drawing

Power Grid Bangladesh PLC

Project: Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)

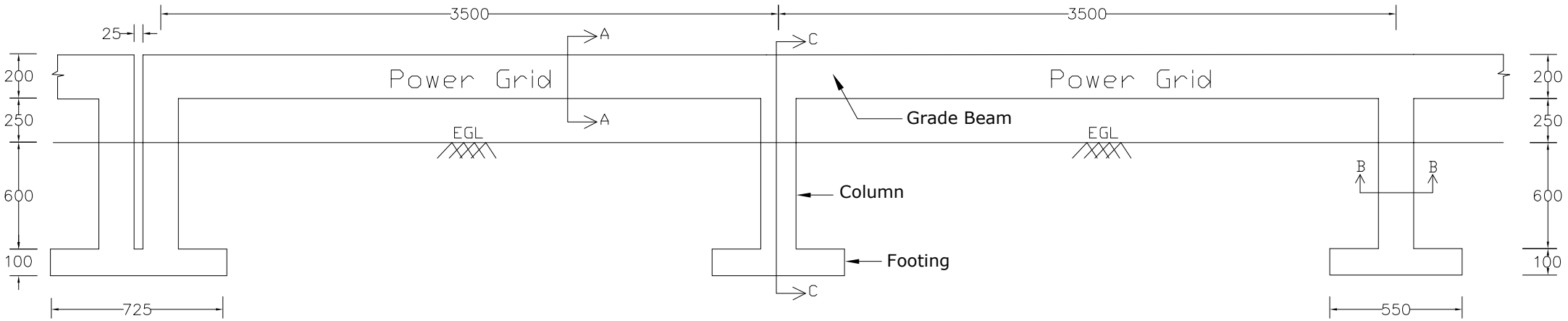
Drawing Title	Ansar Barrack
Drawing No.	PG/ADB/AB
Drawn:	Checked: Approved:



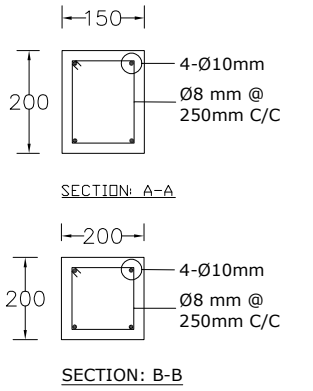
TYPICAL STAIR RAILING DETAILS

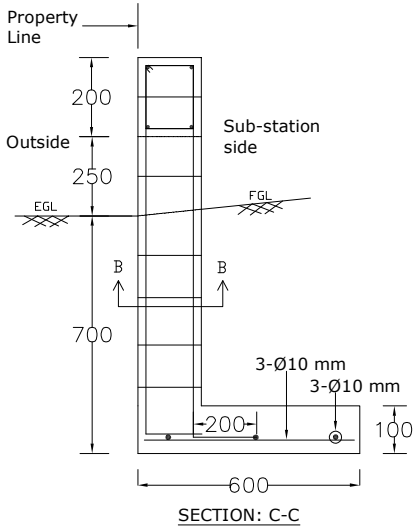
Tender Drawing

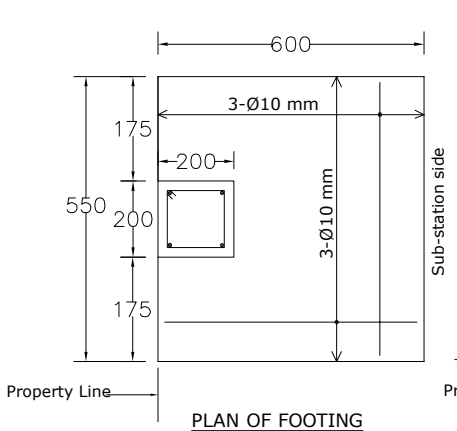
Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Typical Stair Railing
Drawing No.	PG/ADB/SR
Drawn:	Checked: Approved:

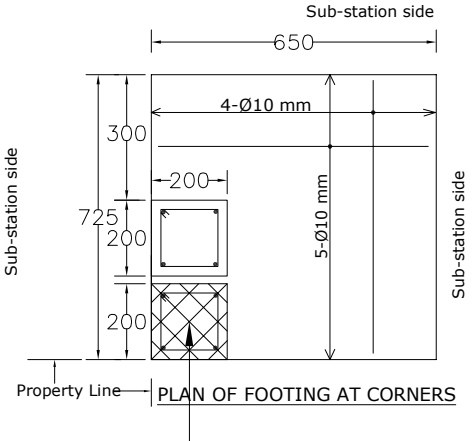


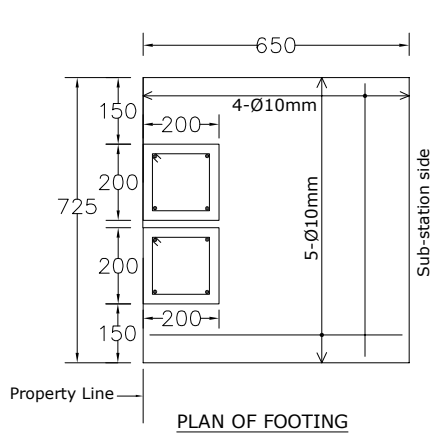
SECION ALONG PROPERTY LINE









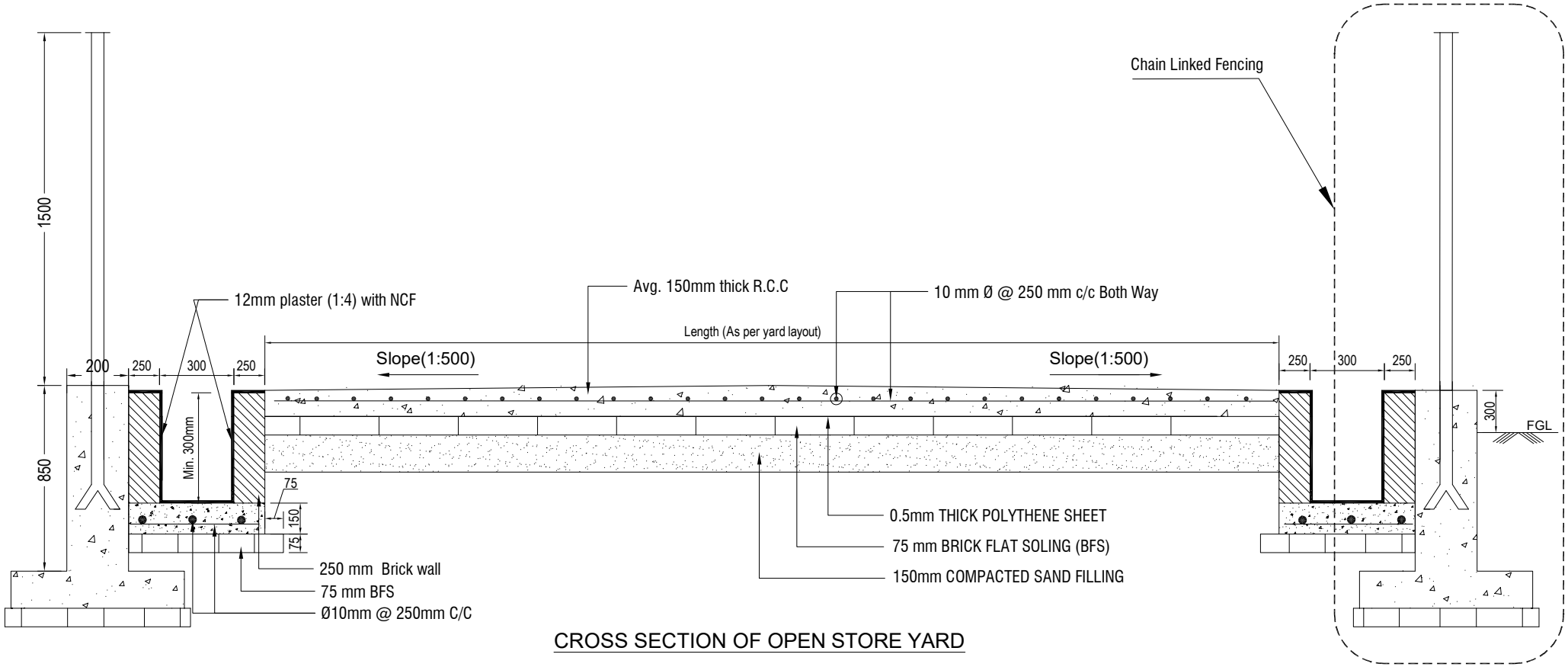


General Notes:

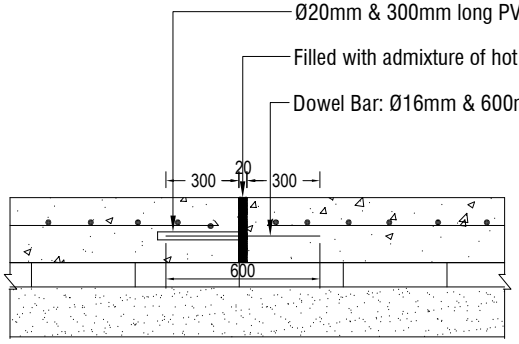
1. Grade beams, columns and footings are Class A Reinforced Cement Concrete(RCC) structures.
2. Grade of rebar shall be deformed bar of Fy 415 MPa minimum.
3. Clear cover both side and bottom: For Grade beam & column= 25mm and for Footing= 40mm.
4. Maximum centre to centre distance of columns = 3500mm.
5. 25mm expansion gap shall be provided at 35000mm interval by double column.
6. All dimension are in mm where not stated.

Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Property Line demarkation
Drawing No.	PG/ADB/PL
Drawn:	Checked: Approved:



CROSS SECTION OF OPEN STORE YARD



DETAILS OF EXPANSION JOINT

NOTES:

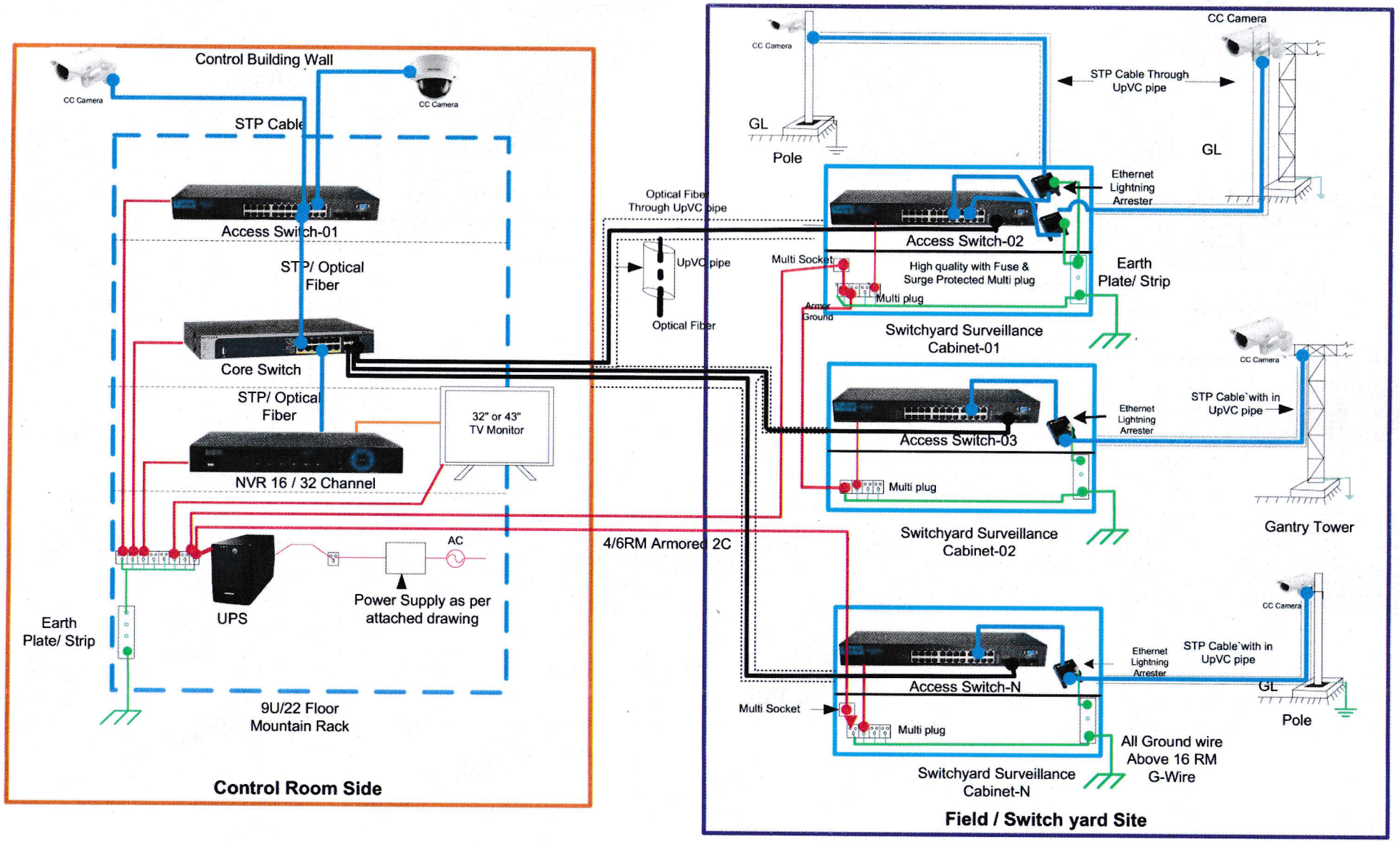
1. EXPANSION JOINTS SHALL BE PROVIDED AT EVERY 6M INTERVAL.

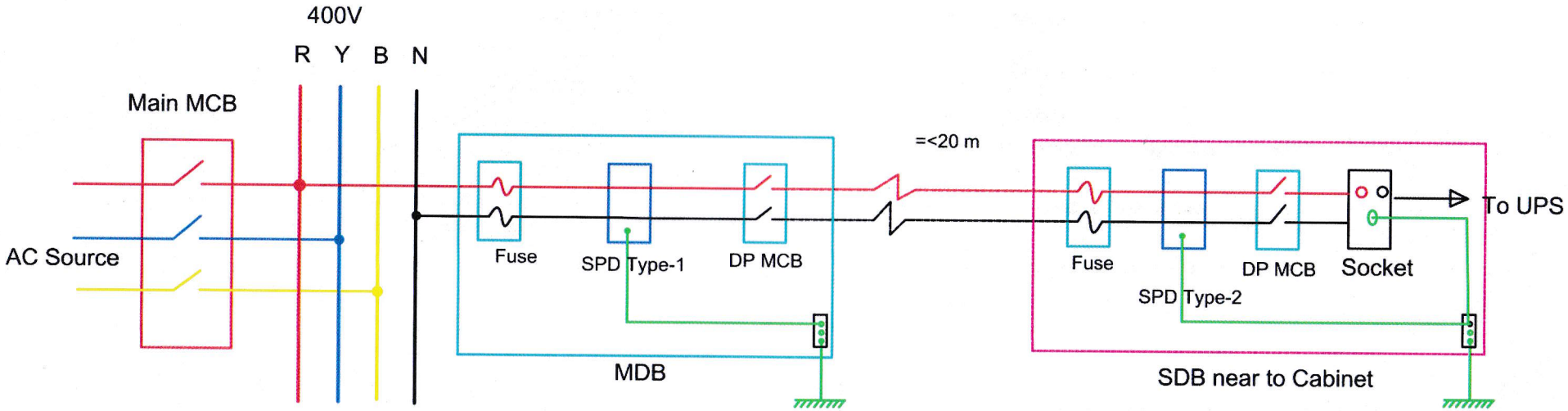
Tender Drawing

Power Grid Bangladesh PLC	
Project:	Design, Supply, Installation, Testing & Commissioning of 230/132/33 kV AIS Substation at Madhabpur and Monohardi including two nos. 132KV bay extension at Bajitpur 132/33kV grid substation and associated 230kV and 132kV Transmission Lines on turnkey basis (Package-2)
Drawing Title	Typical Section of Open Store Yard
Drawing No.	PG/ADB/OSY
Drawn:	Checked: Approved:

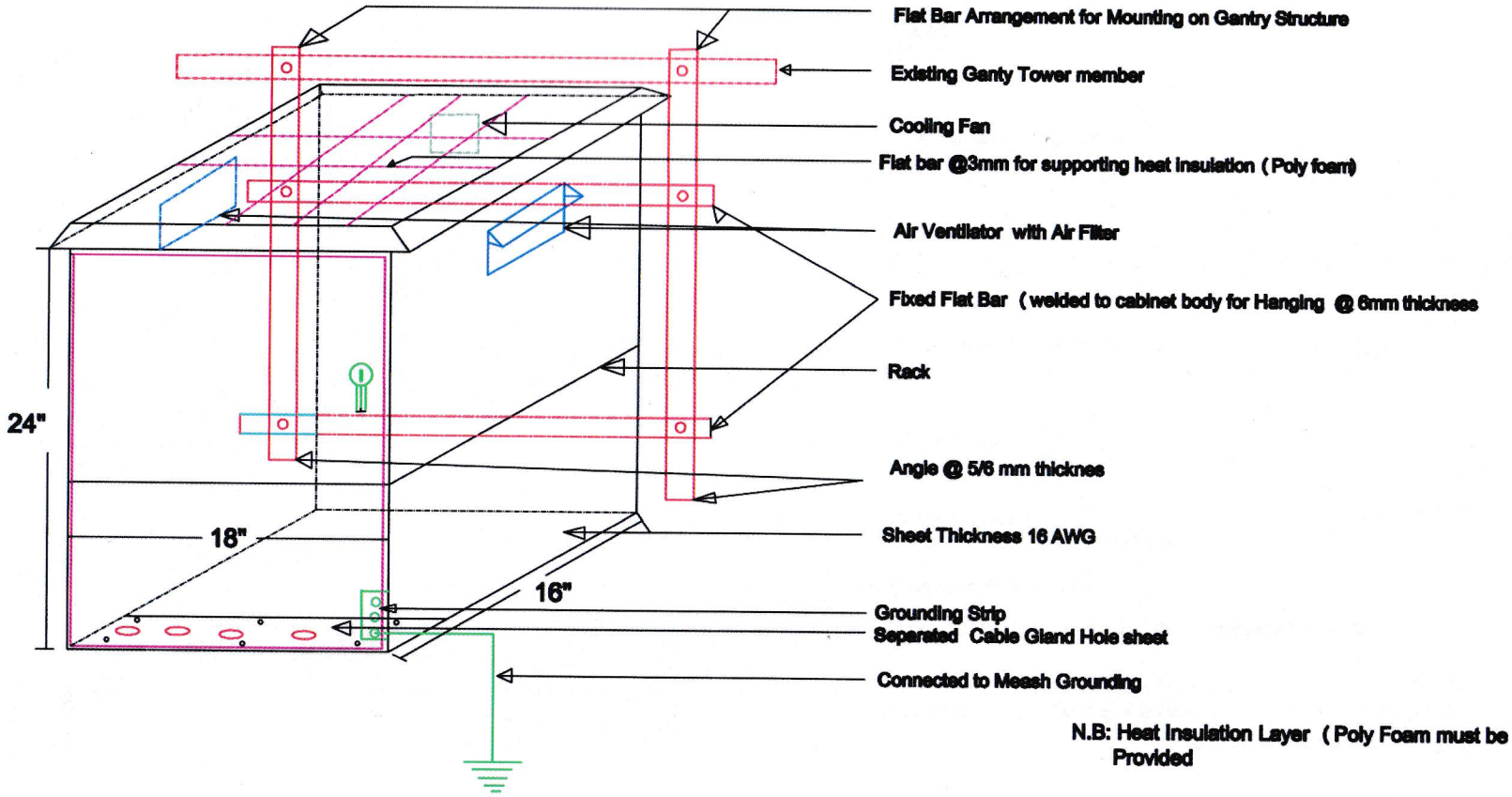
Fig: Layout of IP Camera Surveillance system in a Grid Substation

(For Tender Purpose Only)

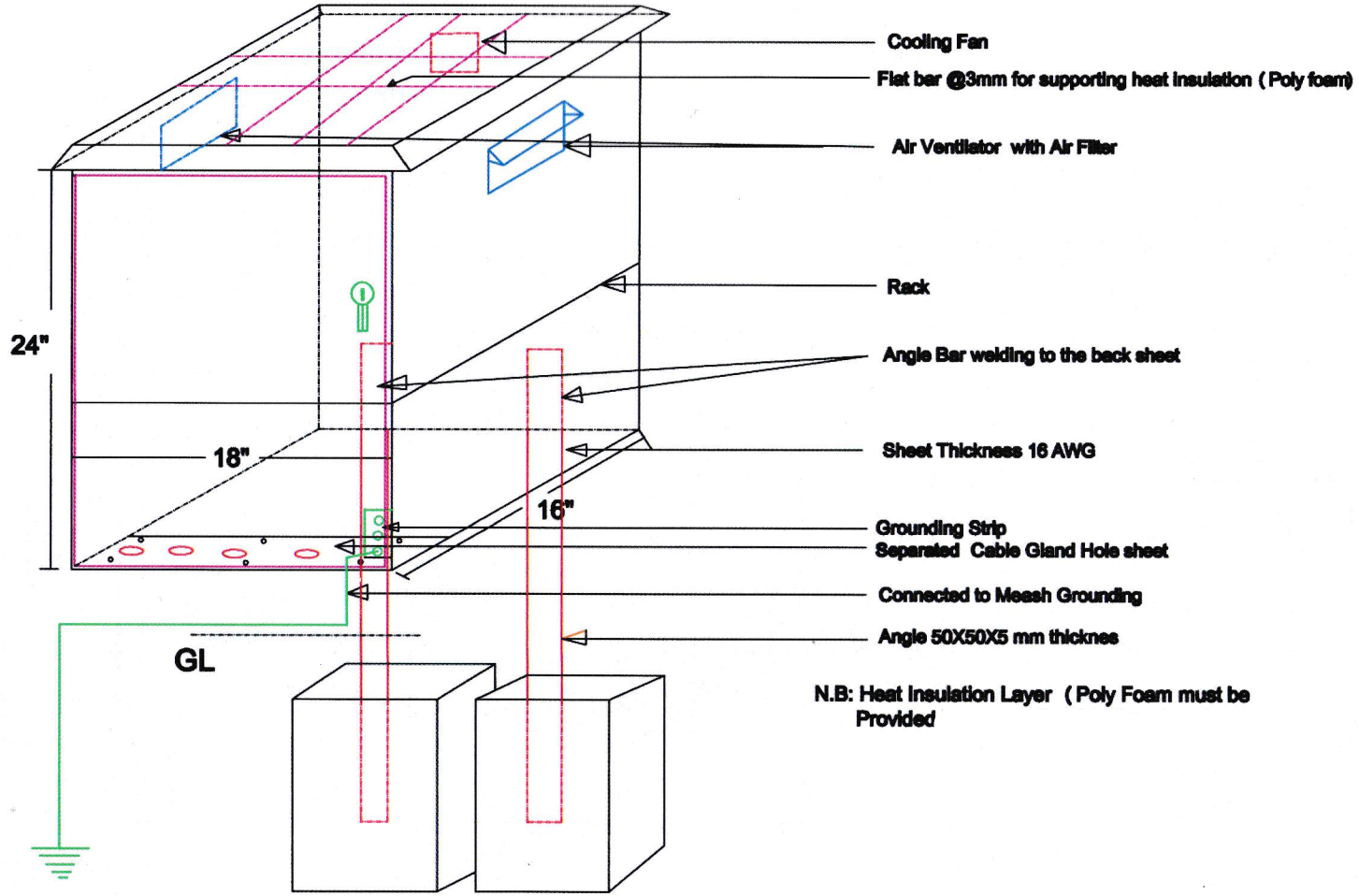




POWER GRID COMPANY OF BANGLADESH (PGCB)	TITLE : LAYOUT OF POWER SOURCE INPUT TO SERVEILLANCE SYSTEM (For Tender Purpose Only)	

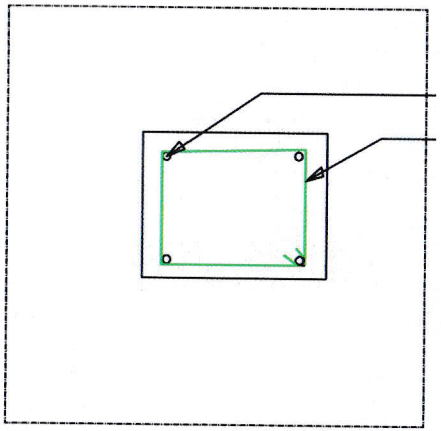


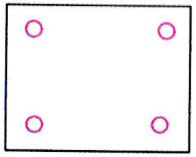
POWER GRID COMPANY OF BANGLADESH (PGCB)	TITLE : **Switchyard Serveillance Cabinet (Hanging type)** (For Tender Purpose Only)	



RCC/CC

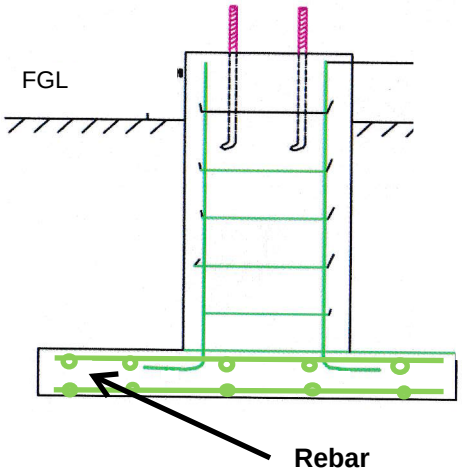
POWER GRID COMPANY OF BANGLADESH (PGCB)	TITLE : Switchyard Serveillance Cabinet (Fixed Type) (For Tender Purpose Only)	

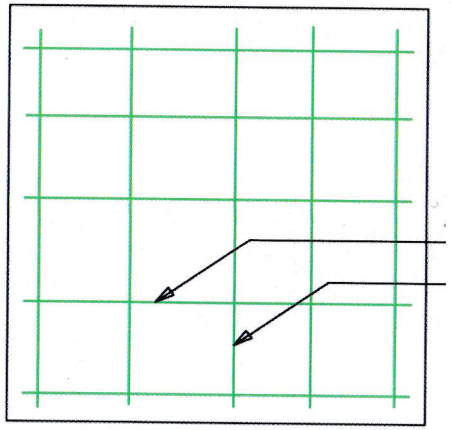




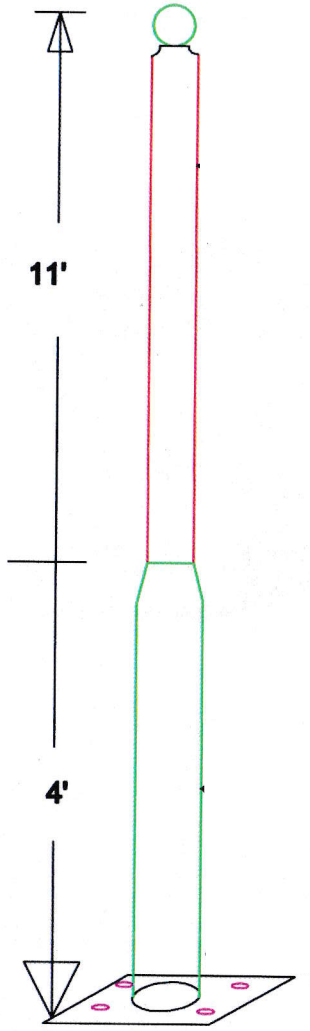
Anchor Bolt Arrangement

Anchor Bolt-





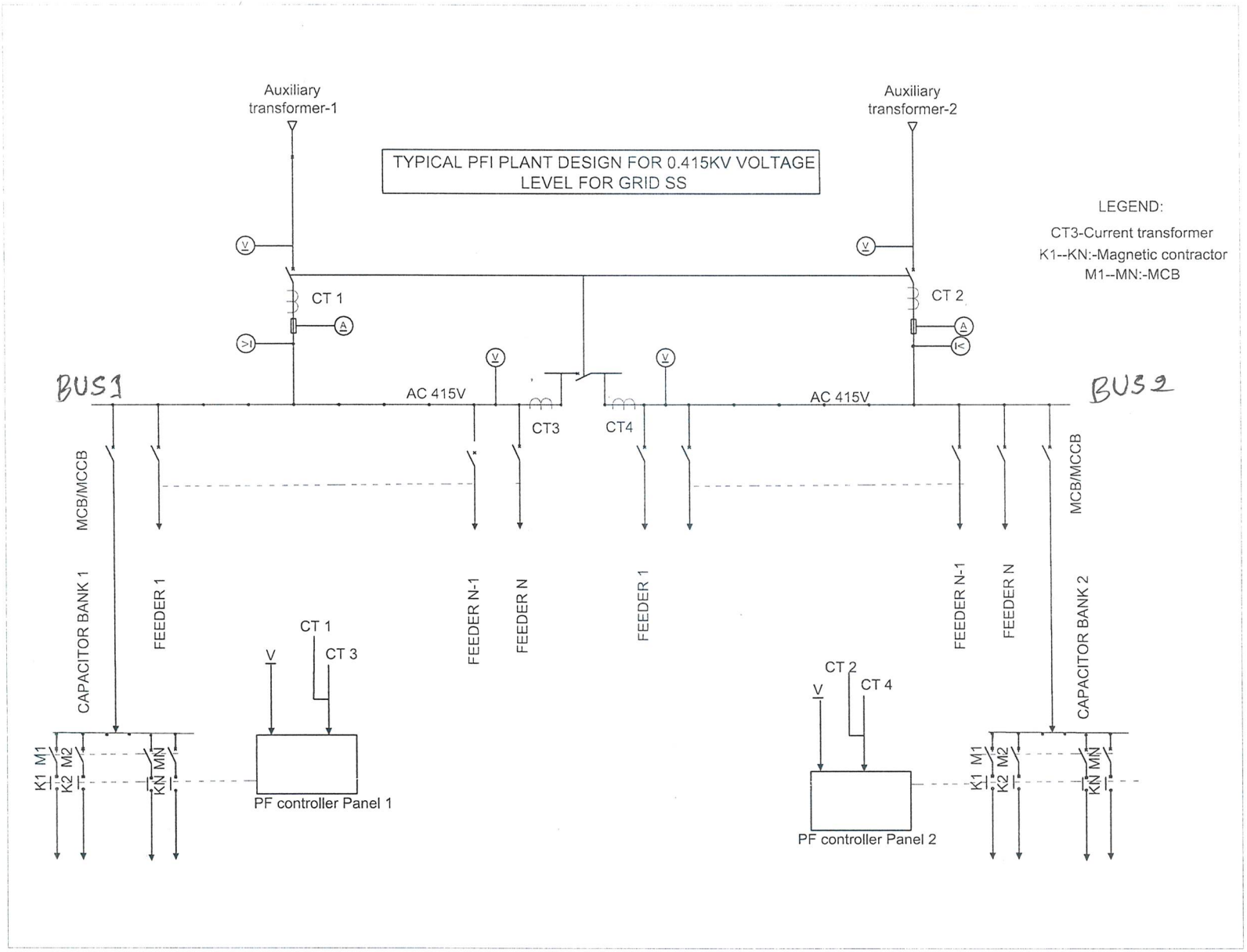
Rebar
(Top & Bottom Layer)



POWER GRID COMPANY OF BANGLADESH (PGCB)

TITLE : Foundation Details of Pole Mounted IP Camera

(For Tender Purpose Only)



Tender Purpose Only

Drawing no: PG/ADB/PFI