POWER GRID COMPANY OF BANGLADESH

BIDDING DOCUMENT
FOR

Design, Supply, Installation, Testing & Commissioning of 400/230kV, 500/750MVA Transformer and associated Switchgear in existing Meghnaghat 400/230kV AIS substation

VOLUME 2 OF 3

Memo No: 27.21.0000.101.07.427.24.2467

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Employer: Power Grid Company of Bangladesh Limited

Country: Bangladesh

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Scope of Supply of Plant and Services

Please refer to Volume 3 of the Bidding Document.

Ancillary Mechanical and Electrical Appa- ratus

2.1 Scope

This section of the technical specifications describes the general requirements for mechanical and electrical designs of all the plant being supplied under the contract, electrical aspects being covered in another Section of the Specification. It shall be read in conjunction with the General Conditions, Draw- ings, the Schedules and other sections of these technical specifications covering particular aspects of the plant. In the event of conflict between the general and special contract requirements, the latter shall take precedence.

2.2 References

2.2.1 ISO Standards

ISO 68	General Purpose Screw Threads
ISO 261	General Purpose Metric Screw Threads
ISO 262	Selected sizes for screws, bolts & nuts
ISO 272	Fasteners-hexagon products-widths across flats
ISO 274	Copper tubes of circular section.
ISO 448	Gas cylinders for industrial use-marking.
ISO 885	General purpose bolts and screws-metric series
ISO 888	Bolts, screws and studs-nominal lengths, and thread lengths
ISO 965 / 1, 2, 3	General purpose Metric screw threads
ISO 4759-1	Tolerances for fasteners
ISO 9000	Quality management and quality assurance standards
ISO 9001	Quality management systems-Requirements

2.2.2 IEC Standards

60034	Rotating Electrical Machines
60038	IEC Standard Voltage
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 up to 15 / 30 kV
60059	IEC Standard Current ratings
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
60228	A 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
60376	Specification and acceptance of new sulphur hexafluoride
60383	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	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	Electricity metering equipment
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
62271-203	Gas-insulated metal-enclosed switchgear for rated voltages of 52 kV and above
62271-209	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 52 kV and above

2.2.3 British Standards

BS EN 10250-2 Specification for Carbon steel forgings
BS 182 Specification for galvanised line wire for telephone & telegraphic purposes
BS EN 10244-2 Specification for testing zinc coatings on steel wire
BS 499 Welding terms & Symbols
BS 709 Method & testing fusion welded joints
BS 729 Specification for hot dip galvanised coatings on iron & steel articles
BS 970 Specification for wrought steels for mechanical & allied Engineering
BS EN 12540 Specification for electroplate coatings of nickel and chromium
BS1710 Specification for identification of pipelines & services
BS EN 837-1 Specification for Bordon tube pressure and vacuum gauges
BS 1858 Specification for bitumen based filling compounds
BS EN 60068-218 Environmental Testing
BS 2569 Pt 2 Protection of iron & steel against corrosion at elevated temperature
BS EN 1435 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
BS 3923 Pt 1 Methods of examination of fused welds and butt joints & Pt 2
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
BS 4479 Recommendations for coatings. Pts 1-9
BS EN 1412 Industrial type flooring, walkways and stair treads
BS 4604 Pt 1-2 Spec for high strength friction bolts
BS EN 10250-3 Spec for alloy steel forgings.
BS 4800 Schedule of Paint Colours for building
BS 4675 Pt 2 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
BS EN ISO 9934 Method for penetrant flaw detection
BS EN 50262 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
BS EN 571-1 Method of penetrant flaw detection.
BS 7079 Preparation of steel substrates before application of paints

2.2.4 BS European Standards

BS EN 287 Approval testing of welders for fusion welding-1 &-
BS EN 288 1-8 2 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, interna- tionally accepted national standards 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 that 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 stand- ards occurring first in the list taking precedence over any standards later in the list:

Statutory regulations of Bangladesh
Standards named in the specification
Other international standards
Other standards approved by the Engineer

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

2.5.4 Substitution of Standards and Design Codes

The Contractor may offer works that comply with international standards, or internationally recognised national codes or standards, which differ from those specified. However the Contractor 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 organisation in question has extensive experience with the alternative code or standard offered.

Any Contractor offering contract works or part of those works to standards and codes that differ from those specified shall declare the fact to the Engineer. If requested to do so by the Engineer, the Con- tractor shall supply to the Engineer, at his own cost, with 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., towers, 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 Contractor 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 manufac- tured 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 authorised 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 Contractor 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 that 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 peri- od.

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 8501-01.

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 test- ed 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 m² of coating surface, the coating need not be re-tested after the defects have been repaired. If the defects exceed one per 5 m² 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 m² of coating surface. After repair of these de-fects, 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 as suitable for use in potable water installations by an approved independent authority 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 Contractor 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 em- ployed does not produce paint films containing vacuoles.

All planished and bright parts shall be coated with grease, oil or other approved rust preventative be-fore 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 that 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 En- gineer 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 Factory" 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 fin- ished 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 build-ings 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 Contractor 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 recommenda- tions of the standards and codes of practice referred to and the paint Manufacturer's special instruc- tions where applicable, colours being in accordance with BS 1710 and BS 4800, or equivalent material standards.

2.7.2 Schedules for Indoor Surfaces Finishes

Treatment at Factory	Treatment at Site after Completion of Erection
General	
Structural and supporting steelwork, plant items above ground, tank external surfaces. All not above 95°C (or 65°C for chlorinated rubber finishes).	
Blast clean to BS 7079 2nd quality (SA 2.5) profile amplitude 40-75 µm. **Then apply within 4 hours one coat (13 µm) weldable holding primer for 12 months x match protection. After fabrication is complete dress all welds, thorough-ly clean to remove corrosion products, oil, grease and dirt and apply one coat (50 µm) of two pack epoxy zinc phosphate primer followed by two coats two pack epoxy micaceous iron oxide (250 µm 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 µm) and one coat alkyd gloss (25 µm)**
(b) Steel floors, chequer plates, galleries, stairways, treads, kick stops.	
Galvanise to BS 729	**Thoroughly clean to remove oil, grease and dirt. Where galvanising is damaged, wire brush to BS 7079 3rd quali- ty (SA2) and apply 1 coat zinc rich epoxy primer (50 µm).** **Then apply:** **1st coat of etch primer** **2nd coat epoxy zinc chromate** **3rd coat 2-pack epoxy micaceous iron oxide (50 µm).** **On galleries and stairwaystop surfaces apply:** **4th coat non-skid epoxy deck paint (30 µm).**

Treatment at Factory	Treatment at Site after Completion of Erection
(c) Galvanised iron and steel requiring paint finish	
Galvanise 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 µm) 3rd coat alkyd undercoat (30 µm) 4th coat alkyd gloss (25 µm).
(d) Stainless steel, aluminium alloys and non-ferrous alloys requiring paint finish.	
Not Applicable	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat alkyd undercoat (30 µm) 2nd coat alkyd gloss (25 µm).
(e) Bitumen dipped items	
Bitumen dipped.	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat general purpose aluminium paint (18 µm) 2nd coat alkyd undercoat (30 µm) 3rd coat alkyd gloss (25 µm).
Battery Rooms (open top batteries), Chlorination Plant Rooms, Electrolytic Cell Rooms	
(a) Steelwork	
Blast clean to 2nd quality BS 7079 (SA2.5) profile amplitude 40-75 µm	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 µm) 3rd coat high build chlorinated rubber (80 µm).
Bright Parts	
Coat with a mixture of oil, grease or approved proprie- polish tary inhibitor.	Clean and
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	
Acid pickle or blast clean to 1st quality BS 7079. Then burnish apply: 1st coat zinc chromate primer (30 µm) Stop and fill. Then apply: 2nd coat alkyd undercoat (30 µm). Rub down with fine abrasive paper. Then apply 3rd coat alkyd undercoat (30 µm) Rub down with fine abrasive paper. Then apply: 4th coat alkyd matt (25 µm) 5th coat alkyd matt (25 µm)	Touch up if necessary and

Treatment at Factory	Treatment at Site after Completion of Erection
6th coat alkyd matt (25 µm) Total film thickness (125 µm).	

2.7.3 Schedules for Outdoor Surfaces Finishes

Treatment at Factory	Treatment at Site after Completion of Erection
General	
Structural and supporting steelwork, plant items above ground, tank external surfaces. All not above 95°C (or 65°C for chlorinated rubber finishes).	
Blast-clean to BS 7079 2nd quality (SA2.5) profile amplitude 40-75 µm. Then apply within 4 hours one coat (13 µm) weldable holding primer for 6 months protection or (25 µm) weldable holding primer for 12 months protection. After the protection period, thoroughly clean to remove oil, grease and dirt and apply one coat (50 µm) of two pack epoxy zinc phosphate primer followed by two coats two pack epoxy micaceous iron oxide (250 µm 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 µm) and one coat alkyd gloss (25 µm)
(b) Steel floors, chequer plates, galleries, stairways, treads, kick stops	
Galvanised to BS 729	Thoroughly clean to remove oil, grease and dirt. Where galvanising is damaged, wire brush to BS 7079 3rd quality (SA2) and apply one coat zinc rich epoxy pri- mer (50 µm). Then apply: 1st coat epoxy etch primer 2nd coat epoxy zinc chromate (30µm) 3rd coat two pack epoxy micaceous iron oxide (100 µm) On galleries and stairways top surfaces apply: 4th coat non-skid epoxy deck paint (30 µm).
Galvanised iron and steel requiring paint	
finish Galvanised to BS 729	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat etch primer 2nd coat zinc chromate primer (30µm) 3rd coat alkyd undercoat (30 µm) 4th coat alkyd gloss (25 µm).
(d) Stainless steel, aluminium alloys and non-ferrous alloys requiring paint finish	
Not applicable.	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat alkyd undercoat (30 µm) 2nd coat alkyd gloss (25 µm).

Treatment at Factory	Treatment at Site after Completion of Erection
(e) Bitumen dipped items	
Bitumen dipped.	Thoroughly clean to remove oil, grease and dirt. Then apply: 1st coat general purpose aluminium paint (18 µm) 2nd coat alkyd undercoat (30 µm) 3rd coat alkyd gloss (25 µm)
Bright Parts	
Coat with a mixture of oil, grease or approved proprie-tary inhibitor.	Clean and polish
Instrument Panels, Control Panels, Marshalling Kiosks, Lighting and Small Power Distribution Boxes and Junction Boxes etc.	
Blast clean, prime, undercoat and paint in accordance with the painting schedule for structural and support-ing steelwork, with finish coat of paint applied at Man-ufacturer's works	Clean and touch up as necessary with the painting schedule for structural and support-ing steelwork,
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 pin-holes and porosity. For oil storage tanks, solvent-free epoxy paint formu-lation shall be used.	
For tanks delivered to site in plate sections, the plates shall be blast cleaned to BS 7079 1st quality (SA3) rough profile amplitude 40-75 µm and then within 4 hours radiused 3 coat with a weldable holding primer dry film thickness mm 25 µm	Welded Construction at Site. After erection all welds shall be dressed to remove edges and burrs and all sharp edges shall be 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 µm 2nd coat Isocyanate or amine cured high build epoxy (125 µm) 3rd coat Isocyanate or amine cured high build epoxy (125 µm).
Sectional Construction: Prior to assembly, all component items to be blast cleaned to BS 7079 1st quality (SA3) profile amplitude 40-75 µm. Then apply: 1st coat Isocyanate or amine cured epoxy primer (25 µm). After assembly, clean all surfaces free from rust, grease and dirt. Priming coat to be touched up as necessary. Then apply:	Sectional Construction: Touch up damaged areas as necessary.

Treatment at Factory	Treatment at Site after Completion of Erection
2nd coat Isocyanate or amine cured high build epoxy (125 µm) 3rd coat Isocyanate or amine cured high build epoxy (125 µm).	
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 Gen- eral Sub-Clause of this Clause. Radiators that 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 Contractor shall supply and install all labels, name, rating, instruction and warning plates neces-sary 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 ex-ists 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 that 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 including 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 ap-proved by the Engineer.

In addition, the device number allocated by the Engineer to each item of plant shall be displayed in text height 30 mm on all operating mechanisms and 60 mm 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 10 mm 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 hand-wheel captive nut. For check valves and small valves, the Contractor 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 se-cured arrow, showing the direction of flow. Pipework shall be provided with plentiful large painted ar-rows 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.

Outdoor plant shall be rated and constructed so that its performance, operation, reliability, mainte-nance and or life shall meet the specified design and operating conditions.

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, in-cluding 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 ambi-ent 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 could sat-isfy 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 en- sure 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 un-der which equipment shall work, and good proven practices shall be followed unless otherwise ap- proved by the Engineer. Some relaxation of the following provisions may be permitted where equip- ment 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 in- struments 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., phos- phor 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 Contractor 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 workers, tools and portions of plant that may be placed on them during overhaul and in- spection periods.

Galleries, platforms and stairways shall be designed generally for a load of 7.5 kN/m² but where loads in excess of this are likely to be imposed during operation or maintenance, the Contractor 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 con- tract.

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 en-closed 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 pro- vided 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 access ways, shall comply with the requirements of BS 5395 Part 3, unless otherwise stated. As far as practical the flooring, stair treads and handrails 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 galva- nised 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 pan- els.

The open grid flooring and stair treads shall be from an approved Manufacturer and generally in ac-cordance with BS 4592. The pattern 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 for 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 galva-nised 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 inter-nal 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. Handrails 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 provi-sions 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 standardised. 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 se-ries 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

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, and they shall have the screwed por-tion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous po- sition to ensure correct assembly at site.

Stud holes in those parts of the plant that 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 assem-blies, 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 re- quired 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 Contractor 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 sur-face defects. The Contractor 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 that shall be transferred through-out 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 that 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 Contractor.

All castings shall be homogeneous and free of shrinkage, pipes, under-sizing, 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-destruct-

ive examination (ultra-sonic, 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 Contractor shall prepare material purchasing specifications for all important castings. Each docu- ment 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 be first obtained. The Contractor shall submit drawings, sketches or photographs showing the location and principal dimen- sions 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 ap- plied to all important castings to locate the extent of sub-surface defects and to check the wall thick- ness.

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 Contractor 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 im-pact, 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 Contractor 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 Contractor shall include for this even- tuality and shall comply with the Engineer's instructions when issued.

2.13.4 Aluminium Bronze Castings

The Contractor shall prepare material purchasing specifications for all important castings. Each docu- ment 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 Contractor shall submit full details of the proposed weld repair pro-cedure 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 radiog- raphy. 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 Speci-fication 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 CO_2 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 Contractor and these shall be made available to the Engineer on request. Prior to commencement of welding the Contractor shall submit to the Engineer for approval the welding procedures to be used in the fabrication of the rele-vant 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, Ap- pendices 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 Contrac-tor 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 interna- tionally recognised inspecting authority may be accepted by the Engineer.

The Contractor 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 Contractor 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' qualifi-cation 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 that in the opinion of the Engineer is unsuitable or unsatisfactory for the pur-pose for which it is being used shall be replaced by the Contractor.

2.14.8 Visual Weld Inspection

Each weld shall be subjected to a stringent visual inspection and shall be free from undercut, exces-sive spatter, craters, cracks, porosity and other surface imperfections. Welds shall be of regular con-tour, even weld ripple and indicative of good workmanship. Fillet welds shall be checked for dimen-sional 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 intra-scope or other suitable optical de- vice.

2.14.10 Non-destructive Examination

All non-destructive examinations shall be supervised by a fully qualified and experienced specialist appointed by the Contractor. 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 and 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 Na-tional 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 sub- jected 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 yield strength greater than 300 MPa, shall be subjected to 100% ul-trasonic examination and crack detection wherever possible. In addition, all butt welds in these mate-rials 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, cut- ting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising pro- cess commences.

All galvanising shall be done by the hot dip process, 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 ac- cordance 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 non-hygroscopic spac-ers 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 Contractor may, after receiving such agree-ment, attempt to affect 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 Engi- neer'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 Contractor 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, i.e. 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

During the contract Engineering, the Contractor shall supply to the Engineer schedules of the pipe- work 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 pip- ing and valve materials, the types of valves, any corrosion allowance, the pipework design code, insu- lation 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 fit- tings. 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 dis- mantling of piping.

The Contractor is to be responsible for ensuring that the internal surface of each pipe line is thorough-ly clean both during erection and before the pipe line is placed in commission.

The procedure for internal cleaning of pipes adopted by the Contractor is to include the following:

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

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

Pipework shall be supported and anchored in an appropriate manner in accordance with the provi- sions 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

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.

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 hand-wheel or other point of application of manual action shall not need to exceed 400 N (normally 200 N pull plus 200 N 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 hand-wheels in a clockwise direction when looking at the face of the hand-wheel. In cases where the hand-wheel is not directly attached to the valve spindle suitable gearing shall be introduced to ensure clockwise closing. The face of each hand-wheel shall be clearly marked "open" and "shut" or "closed" with arrows indicating the direction of rotation to which they re-fer.

Plastic valve hand-wheels will not be acceptable, except where such hand-wheels are in the Employ-er'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 50 mm 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 mechani-cal damage and dust or dirt.

Valves that 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 na- tional pressure vessel design codes, unless the vessel in question falls into one of the following groups:

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.

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

- a heat input of 58kW
- a water temperature of 93°C
- a nominal water containment capacity of 454 litres.

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.

vessels having an internal diameter not exceeding 150 mm.

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, 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 de- sign code shall be provided.

In respect of the design codes to which "coded" vessels shall comply, attention is drawn to the provi- sions 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 opera- tion 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 operat- ing and maintenance instructions. In the case of grease lubricated roller type bearings for electric mo- tors a lithium based grease is preferred.

The Contractor shall 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 shall 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°C 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 pres-sure 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 posi- tions as may be determined to suit the operation and testing of the plant to the approval of the Engi- neer. A thermometer pocket is to be fitted adjacent to each point of connection for distant remote tem- perature 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 3 mm. The construction shall employ folding technique with the use of standard rolled sections or other reinforcement where necessary. The stiff-ness shall be such as to prevent mal-operation 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:

Control position selector switches in all positions provided, except where other electrical or me-chanical interlocking is approved.
Marshalling, operating and terminal kiosks or cubicle access doors and panels. 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 particu-lar 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 de-sign shall be supplied for the accommodation of all padlocks and/or keys while not in use. The pad-locks and keys shall be engraved with an agreed identifying code or inscription and this shall be re- peated 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 re-main 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 per- sonnel 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 in- terior of equipment.

Corresponding parts of similar equipment, and equipment liable to renewal, shall be fully interchange- able and the Contractor 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 standard 61000.

All electrical components shall be adequately rated for their most onerous duty and the specified am-bient 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, rat-ed or de-rated 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 oth- erwise specified, minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows:

Indoors only in totally enclosed rooms with provision for limiting ingress of dust:	IP 31
Indoors, except as noted otherwise:	IP 54
Outdoors, and indoors in areas subject to water spray, or heavy condensation:	IP 55W

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 En- gineer.

Every current carrying part of the equipment shall be capable of carrying its site rated current continu- ously under the site ambient conditions as specified and shall not be rated on the basis of air condi- tioned rooms even when these are specified. In no conditions shall the specified maximum tempera- ture be exceeded.

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

2.28.2 Temperature Rise

Full provision shall be made for solar heat gain on all outdoor apparatus and any differential tempera- tures 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 tempera- ture rise shall be reduced by one degree Celsius for every degree Celsius the maximum ambient tem- perature 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°C from the standard value in IEC60076.

In such cases where the Contractor 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 Contractor shall submit his calculations to the Engineer to prove that all plant has been sufficiently de- rated to suit the site conditions and any changes required by the Engineer shall be made at no ex- tra 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 else- where 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 per- manent 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 ±10% 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°C

2.29.2 Short-Time Voltage Ratings

All electrical equipment shall be so designed such as to withstand abnormal system voltages as re- quired 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 Na- tional 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 hygro-scopic 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 resis-tors, 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 Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums. The Contractor shall provide at no additional cost any oil treatment facilities he may re- quire 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 posi- tion and without a locking feature. Circuit breakers shall have control switches which shall be labelled open/N/close or (0/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 con-trolled device is at variance with the position indicated by the control switch. Hand dressing of the con-trol switch to the correct position shall cause the lamp to extinguish.

Pushbutton test switches shall be provided along the control panel that will illuminate all indicating dis-crepancy 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 dia-grams. 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 simulta-neously, 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 instru-ment or control equipment, viz. main control room desks and panels, and electrical equipment cubi-cles.

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 appear- ance, 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 tropicalized as appropriate.

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 emer- gency trip contacts can be set so that mal-operation will not be possible due to any vibrations or im- pacts 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 instru- ments 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 pan-els for maintenance purposes.

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

For suites of panels inter-panel bus-wiring 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 Con-trol 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 5Y7/1 col-our. 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 60051-1.

Unless otherwise specified, all indicating instruments shall have 96 mm or 144 mm 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 62053 and other relevant IEC standards and, unless other- wise specified, shall be of accuracy Class 1, except Class 0.2 for energy meters. 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 standards.

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 ac-curacy to IEC standards.

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 trans- formers 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 kilo- watts the value of the impulses received from each kilowatt-hour meter. Printometers shall be of an approved type having the specified demand interval.

Each 400 kV and 230 kV feeder shall be provided with 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, from either 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 re-quirements.

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 emit-ting diodes, are used in place of lamps then these shall have the same life expectancy and perfor-mance 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 materi-als 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 illumi-nate in accordance with the above colour code after the instruction has been carried out and the de-vice 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 pro- tected 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 cu- bicle and bus-wired 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 bus-wired 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, Cable Terminations 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:

Class 1: conductors up to a maximum of 0.9 mm diameter where necessary for wire-wrapped ter-minations and similar techniques,
Class 2: conductors except where specified otherwise,
Class 5 and Class 6: conductors between points subject to relative movement.

The following minimum conductor sizes shall be used:

1.5 mm² except where specified otherwise,
2.5 mm² for potential transformer(PT) secondary circuit , control & protection circuit
4 mm² for current transformer secondary circuits .

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 that allows easy access for fault finding and facili- tates the installation of additional wiring.

Small wiring passing between compartments that 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 cur-rent 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 Contractor 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 associ- ated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colours, ex- cept 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 IEC standards or with a func- tional marking system. Both ends of every wire and core in control and instrument cables shall be fit- ted 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 ac- ceptable.

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 multi-pair 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 sepa- rated 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 retain- ing 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 150 mm above the gland plates, and spaced not less than 100 mm 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 difficul-ty 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 sepa- rate 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 in- ternal or external wiring from the block.

The Contractor 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 Engi-neer's approval.

The Contractor 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 else- where.

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 en- able 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 25 mm above the gland plate to avoid moisture col-lecting 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 Contractor 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 500 A, 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, insulat-ed 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 compres- sion 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 4 mm² 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 se- cond 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 insula-tion. 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 Contractor 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 un-armoured 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 Contractor. The Contractor shall supply all compound required together with an ad-ditional 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 ad-equately pre-warmed to drive off moisture.

The Contractor 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 Contractor's expense.

2.40 Oil or Compound-Filled Chambers

All joints of oil- or compound-filled fabricated chambers, other than those that 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 accu- rately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bond- ing 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 ter-minated 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 nec- essary 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, 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, 60981 and 61035. Installations shall also be compliant with local regulations, unless otherwise approved by the Engineer.

All conduit and conduit fittings shall comply with IEC 60423 and IEC 60614. Unless otherwise ap-proved, all conduit and conduit fittings shall be threadable steel conduit with minimum enclosure clas-sification 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 fit-ted 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 10 m 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 61084.

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 inter- mittent or short time duty cycle can be accurately defined by the Contractor.

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 60034-1. 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 60085. All motors shall have Class F insu- lation 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 60034-1 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 60034 (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 be- tween 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 equip-ment. 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 ap-proved 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 Manufac-turer to meet his guarantees.

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

IC4AIA1 or IC5AIA1 for LV motors, or IC4AIAO for small power LV motors. IC4AIAl, IC5AIAI, 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 materi-als 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 ser-vice, 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:

- **Main (line) connections.**
- **Star point connections.**
- **Anti-condensation heater connections.**
- **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 that restricts internal faults to earth faults only. Where pressure relief terminal boxes are used, they shall be designed to re- lieve 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 appli- cable, 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 that are to operate from batteries shall be capable of operating under the service condi-tions 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 brush-gear that does not require to be moved to suit load condi- tions.

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 shut-ter doors, and where approved by the Engineer, separately mounted starters for motors may be pro- vided. 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, me- chanically 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 associ- ated apparatus for minor motors shall be capable of operating without overheating for all specified mo- tor 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 30 kW 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 re- quired.

For motors above 30 kW starters shall not be wall mounted but included in a switchboard. 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 incorpo- rated 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 re- cessed 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, unless required otherwise by the Engineer:

- **both buttons shall be coloured black**

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 classifica- tion 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. Loca-tion of ammeters shall be agreed with the Engineer.

Any necessary pushbuttons used on covered desks, panels etc. have to be of special types (e.g. min- iature, 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 pushbut-tons 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, requir-ing 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 regard- less of the control position selected.

The contacts of all pushbuttons shall be shrouded to minimise the ingress of dust, and accidental con- tact, 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 isolat-ed 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 re-production 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 150 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 2.5 mm² cross-sectional area, or by other means to the approval of the Engineer.

If the plant contains electronic equipment that 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 sys- tem shall be agreed with the Engineer.

3. HV Switchgear and Neutral Earthing Equipment

3.1 Scope

These clauses describe the general technical requirements for the new 400, 230 kV and 33 kV Air In-sulated Switchgear (AIS) and shall be read in conjunction with the project requirements, schedules and drawings in the specification.

The Contractor shall demonstrate that the switchgear has been designed, built and installed in ac- cordance with the relevant international standards and the specification. It shall also operate and per- form 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 han-dling equipment shall be as stated in the Bid document. All devices necessary for operation and earth-ing 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

Except where modified by this specification, the switchgear and/or accessories shall be designed, manufactured and tested in accordance with the latest IEC Standards and other publications quoted in these Standards.

IEC 60044	**Instrument transformers**
IEC 60060	**High voltage test techniques**
IEC 60071	**Insulation coordination**
IEC 60099	**Surge arresters**
IEC 60137	**Bushings for alternating voltages**
IEC 60265-1	**High-voltage switches - Part 1: Switches for rated voltages above 1 kV and less than 52 kV**
IEC 60265-2	**High-voltage switches. Part 2: High-voltage switches for rated voltages of 52 kV and above**
IEC 60269	**Low voltage fuses**
IEC 60273	**Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V**
IEC 60282	**High voltage fuses.**

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 60358	Coupling capacitors and capacitor dividers
IEC 60364	Electrical installation of buildings
IEC 60376	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment
IEC 60383	Insulators for overhead lines with a nominal voltage above 1000V
IEC 60815	Guide for the selection of insulators in respect of polluted conditions
IEC 60865-1	Short-circuit currents - Calculation of effects
IEC 61639	Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above
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 - part 1: common specifications
IEC 62271-100	HV switchgear and controlgear - part 100: AC circuit breakers
IEC 62271-103	Switches for rated voltage above 1 kV and less than 52 kV
IEC 62271-104	Switches for rated voltage of 52 kV and above
IEC 62271-102	HV switchgear and controlgear - part 102: AC disconnectors and earthing switches
IEC 62271-200	HV switchgear and controlgear - part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
IEC 62271-203	HV switchgear and controlgear - part 203: Gas insulated metal-enclosed switchgear for rated voltages 52 kV and above
IEC 62271-209	HV switchgear and controlgear - part 209: Cable connections for gas insulated metal-enclosed switchgear for rated voltages of 52 kV and above

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 National Load Dispatching Centre (NLDC) at Rampu-ra.

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:

- **Local control cubicle to equipment - control of circuit breakers, disconnectors and earthing switches where power operated, complete with electrical indications, mimic diagram, gauges and alarm an-nunciator.**
- **Remote control panel in the control room on each substation site - control of circuit breakers, dis-connectors and earthing switches where power operated, complete with electrical position indica- tions, mimic diagram 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 of SF_6 gas from any compartment, equipment shall withstand rated voltage with SF_6 at atmospheric pressure.

The insulation levels shall be able to withstand 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(not applicable)

Maintenance, repair or extension (MRE) and HV testing on one busbar with directly connected appa-ratuses shall be possible with the other busbar in normal operation.

MRE testing on one switchgear bay shall be possible with all other switchgear bays in normal opera-tion on one busbar.

MRE testing on/of bus coupler 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 installation 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 De-partures in Volume 3.

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 perfor- mance of adjacent circuit breakers or any associated equipment.

The Contractor 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, mainte-nance 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.

Insulation creepage distances shall not be less than 25 mm per kV of rated voltage between phases.

The Contractor shall be responsible for ensuring that insulation co-ordination in accordance with rec-ommendation 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 circuit breakers, disconnectors, current trans-formers, busbars, connections, contacts and joints shall be capable of carrying its specified rated cur-

rent 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 rated in-stantaneous peak currents and rated short time current.

3.4.3 Corona

Equipment shall be designed so as to minimise corona or other electrical discharge and radio interfer- ence. The Contractor is to confirm and ensure adequacy of design in terms of corona performance. Tests for corona and radio interference shall be carried out by the Contractor as per relevant IEC standard.

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 Contrac-tor shall include the supply and fitting of the necessary auxiliary switches for remote position indica-tion.

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

This specification of technical conditions and technical requirements for Circuit Breakers covers the ratings, design, equipment requirements, inspection and testing of the equipment.

Here are stated only those general aspects that are meant to ensure minimum requirements with re- spect of quality and performance.

Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the rele-vant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specif- ically in the following specifications.

General Design

Circuit breaker shall be, for outdoor installation. The circuit breaker shall be with SF6 gas as the arc-quenching and insulating medium. The circuit breakers shall comply with the requirements of IEC 60273, IEC 60694, IEC 60815, IEC 62271-100.

Beside the rated short circuit breaking current, the circuit breakers shall be capable of making and breaking the excitation all currents, without restricting and generating harmful over-voltage.

Circuit breakers with two breaking chambers shall be constructed to provide voltage distribution per breaking unit not above 55 % of the total voltage, at any circumstances.

The Contractor shall provide and deliver suitable horizontal and vertical supporting structure that shall be galvanized

Operating Mechanism

The operating mechanism shall be of motor wound-spring charged type. Other type operating mecha-nism is not allowed. Operating mechanism shall be of maintenance free type.

Operating mechanisms housing shall be made of aluminium or stainless steel. Anticorrosion protection is not anticipated.

It shall be possible to charge the operating springs with the circuit breaker in either the open or closed positions.

In normal operation, recharging of the operating springs shall commence immediately and automati-cally upon completion of the closing operation.

While a spring charging operation is in progress, closure shall be prevented.

Release of the springs shall not be possible until they are fully charged.

Manual spring release shall be provided.

The operating mechanism shall have hand and electrically charging.

The operating mechanism shall have hand charging facility and it shall be possible to discharge the operating springs, at site, from a charged condition without difficulty.

The state of charge of the operating springs shall be indicated by a mechanical device which shows "spring charged" when operation is permissible and "uncharged" when operation is not possible. A provision shall be made for remote indication of "spring charge fail" conditions. Therefore, a spare spring-drive limit switch contacts and necessary time delay relays shall be provided. The charging motor shall be connected to the a.c. supply.

The control circuits shall be connected to the d.c. supply.

The state of charge of the operating springs shall be indicated by a mechanical device which shows "spring charged" when operation is permissible and "uncharged" when operation is not possible.

At the bottom of each operating mechanism cabinets provide the option of earthing together with the earthing rails, by using the copper wire Cu from the outer side. Connection of Cu earthing rail shall be adapted to Al material of operating mechanism using appropriate material (electrolytically between Cu and Al).

Detachable plates for cable insertion rings shall be provided at the bottom of each operating mecha- nisms cabinet.

Mechanically endurance of circuit breaker shall correspond to class M2.

High Speed Reclosing

The circuit breakers shall be constructed for high speed reclosure of the three poles simultaneously or of a single pole at a time, as per the Technical Schedules.

Reclosing applies only to the circuit breakers used for transmission line feeders.

The operating mechanism shall be suitable for auto-reclosing (cycle 0 - 0.3 s - CO - 3 min - CO).

After loss of power supply the operating mechanism shall be capable of performing a complete cycle.

Control Circuits

All 400kv Circuit Breakers shall be equipped with Controlled Switching Device (or point-on-wave switching devices) for each phase separately. Line side CB and tie CB shall be equipped with CSD plus PIR(Pre insertion resistor) .this shall be read in conjunction with specific GTP.

The Controlled Switching Devices shall be self-monitoring and adaptive so as to correct the timing to meet the closing time objective within 2ms or less.

An alarm shall be issued if the timing is in error by more than 2ms.

Circuit breaker shall be equipped with one closing coil per phase. The closing coil shall be supplied with anti-pumping devices. Circuit breaker shall be equipped with two electrically independent trip coils per phase. The trip coils shall be suitable for application of trip circuit supervision relays.

Means shall be provided to prevent the mechanism from responding to a closing signal when the trip coils is energized.

Circuit breaker shall be designed and equipped with, at least, the following control devices that should be situated in each central control panels:

Open and close push buttons.

Local/remote selector with possibility to be locked in "neutral" position. In neutral position provide appropriate signal.

The control circuits shall be designed to operate under the following conditions:

Remotely, from a National Load Control Centre,

Remotely, from a substation control building,

Automatically, by the protective relays,

Locally, by electrical push buttons,

Locally, by mechanical arrangement.

Each pole of the HV line feeder circuit breakers shall have, its own distinct operating mechanism with the controls grouped in a central control cabinet.

The circuit breaker shall be designed taking into consideration the following points:

The circuit assigned to the closing coil and the first tripping coil shall be separate from the circuit assigned to the second tripping coil. This means that there are two different d.c. supplies.

Power supply for the motor operated mechanism shall be protected by moulded circuit breakers. It is not allowed to cut-of neutral conductor.

Provide enough number of contacts of densimeter to fulfil previous preconditions.

Protective tripping of the circuit breaker shall not be blocked by the selector switch "Local/Remote". A "Manual/Local/Remote" selector switch shall be provided in the central control cabinet.

A manual operating crank for each circuit breaker mechanism shall be provided.

Close-Trip" push buttons shall be provided in the central control panel.

Housing protection shall be at least of IP54.

A anti-condensation element, shall be provided in each operating mechanism housing and central control panel.

Provide anti-pumping devices.

A time delayed adjustable alarm contact for "phase discrepancy" condition shall be provided.

Auxiliary Contacts

The Manufacturer shall provide, for each mechanism, the sufficient number of normal close and nor-mal open mechanically operated auxiliary switches, but at least 20 percent spare and not below amount specified in the Technical Schedules.

Position Indicator

A visual, mechanical, circuit breaker "Open-Closed" position indicator clearly visible from the ground level and without the opening of any access door, shall be provided. It shall be positively driven (cord drives excluded) directly from the mechanism.

Operating Counter

Each operating mechanism is to be equipped with an operation counter.

SF_6 Gas

The circuit breaker shall use SF_6 gas as the arc-quenching and insulating medium. Depending on the design, each pole or complete circuit breaker shall have at least:

Temperature compensated densimeter. Densimeter should be so designed to allow easy check correctness contacts of densimeter. Pressure device must be temperature compensated.

Device must so designed to allow easy reading of a gas density, for each pole or complete circuit breaker, without need for opening of operating mechanism housing or control panel housing.

Sufficient quantity of SF6 gas should be delivered for the first filling and additionally 20 % for even-tually refilling.

One gas leakage alarm signal (S1) and one interlock signal (S2).

High-voltage Terminals

High-voltage terminals shall be:

horizontal,

flat,

for aluminium conductor,

minimum area of 200 or 100 x 100 mm.

with minimum eight or four holes 14 mm diameter, at 50 mm distance between each other.

Cables

The Contractor must deliver factory-prepared-and-tested all necessary equipment (cables, connectors and similar) for mutual connection all operating mechanisms of circuit breakers and central control panel of a circuit breaker (if exist). Cables must be only for connection between operating mechanisms and central control panel. Cables should be for outdoor installation, equipped with appropriate con- nectors for fast and reliable erection of circuit breaker.

Terminals for connection of cables within operating mechanism and central control panel must be equivalent to PHENIX type UK6N and UK10N.

Provide a sufficient space for cables entrance inside operating mechanism and central control panel.

Support Metal Structure

Circuit breaker must be delivered with factory-prepared horizontal and vertical supporting structure necessary for erection. Metal structures shall be galvanized.

Final design of construction will be subject of later agreement. Metal structures shall be galvanized with minimum 70µm zinc layer.

Environmental Protection

Design of circuit breakers shall be designed to take maximum care of environment.

Insulators

Insulators shall be made of brown porcelain, according to technical specifications. Any connection be- tween porcelain and flange shall be made with Portland cement. The connection itself shall be han- dled with such manner so as to prevent retaining or intrusion of moisture. During Acceptance tests Manufacturer shall present a type and routine test report of porcelains. Minimum creepage distance is 25 mm/kV.

Nameplates

Nameplates should have data written in English language:

Manufacturer name

Country of origin

Applicable standard

Type of circuit breaker

Type of operating mechanism Rated voltage

Rated lighting impulse withstand voltage

Rated switching impulse withstand
voltage Rated frequency
Rated current
Rated duration of short circuit
Rated short time withstand current
Rated short time withstand current of a no-load
OHL Average making time
Rated operating sequence
Rated gas pressure on
20°C Mass of a SF_6 gases
Weight of a circuit breaker
Year of production
Factory number
Factory number (numbers) of operating mechanisms

Special Equipment and Tools

The Contractor is obliged to deliver all equipment and tools required for installation, dismantling, test-ing and maintenance of equipment. Special equipment and tools shall be of the highest quality and suitable for field work.

A handle for manual winding shall be found in all operating mechanisms.

All materials to be used shall be new. A list of a special equipment and tools shall be delivered with a bid. The Employer reserves the right to request any other special equipment or tools during training or testing, which he finds necessary, free of charge, although such equipment or tools were not on the list of special equipment and.

Spare Parts

Contractor is obliged to enclose with the bid a list of recommended spares required for operation and maintenance necessary for 10 years period.

Packing, Shipment and Transportation

The Contractor is obliged to arrange preparation, packing and transport of the equipment.

Each circuit breaker shall be separately packed. It is not allowed to pack parts for more circuit break-ers in single package.

The equipment shall be packed and ready to be stored for a longer period. All operating mechanisms shall be provided and packed so as the heater can be connected. For this purpose provide a suitable cable with a plug.

Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

Routine tests shall be performed on each piece of equipment to be supplied, for the purpose of re-vealing faults in material or construction.

Type Tests

Refer to volume 01

Routine Tests

As per IEC STANDARD

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.6 HV Disconnectors

This chapter covers the ratings, design, equipment requirements, inspection and testing of the equip- ment. It states only those general aspects that are meant to ensure minimum requirements with re- spect of quality and performance. Other details and specific data are contained in the technical data schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the rele-vant IEC and British standards. The Contractor is obliged to provide complete equipment, even if the details are not mentioned specifically in the following specifications.

General Design

Disconnectors shall be for outdoor installation, double column, centre break or three column with cen-tre rotated insulator, double break. Disconnectors shall comply with the requirements of IEC 60129, IEC 60265, IEC 60273, IEC 60694, IEC 60815, IEC 62271. Insulators shall be porcelain, brown colour and follow the dimensions ad characteristics defined in the technical specifications.

Operating Mechanism

Disconnectors without earthing blade shall have three or one operating mechanisms, compliant to the technical specifications.

Disconnectors with earthing blade shall have six or two separate operating mechanisms, compliant to the technical specifications. It is not allowed that drive mechanisms of main and earthing blades be lo- cated in the same housing.

Operating mechanisms housing shall be made of aluminium or stainless steel. Anticorrosion protection is not anticipated. Operating mechanism shall be easily accessible constructed for exchange needs. All operating mechanisms shall be motor driven, providing the option of manual operation, too. Motor shall be maintenance-free unit. Motor protection shall be provided with miniature circuit breaker (MCB) having alarm (signalling) contact. Alarm for MCB outage shall be provided. If three-phase MCB is used, the circuit shall be made through all three contacts. Neutral phase shall not be interrupted. After the MCB, the motor circuit shall be positioned with the voltage presence controller (voltage detector relay). Control voltage for electric controls of the disconnector shall be conditioned by the presence of voltage for the motor supply

Alarm (signalling) and control voltage shall be 110/220V, DC. Control over disconnectors shall be two-pole, i.e. both polarities shall be interrupted in control circuits. Selection switch for local/neutral (manual)/ remote controls shall be provided in each operating mechanism. Suitable push buttons shall be pro- vided on all control operating mechanisms.

Option of mechanical blocking and locking of disconnector at both work positions shall be provided. Blockings shall have latches (bolts) for prevention of electric operation in case of manual manipulation, when crank of manual unit is put in work position.

Provide that the crank for manual operation cannot be inserted if the selection switch has not been put in manual position. When the crank is inserted, the electric control over disconnector shall not be pos- sible regardless to the position of selection switch.

All operating mechanisms shall be equipped with heater to prevent condensation.

All operating mechanisms shall have lighting, with automatic switch located at the door of the operat-ing mechanism.

Heater and lighting shall be for 230 V AC, 50 Hz.

The circuits for supply of heater and lighting and socket shall be independent from the circuits for mo-tor supply.

All operating mechanisms shall be equipped with manual control regardless to the type of operating mechanism.

A crank for manual control shall be found in each operating mechanisms.

Secondary connections must be made on terminal connections. Terminal connections shall be made of best material. For AC circuits it shall be for 16 mm2 conductors and for other circuits it shall be for 6 mm² conductors.

All operating mechanisms shall have copper latches at the bottom of the cabinet for earthing of the cable sheath.

Detachable plates for cable glands shall be provided at the bottom of each operating mechanisms cabinet. Housing protection shall be at least IP 54. Operating mechanism housing shall have electric scheme on inner side of the door.

Control Circuits

Disconnector shall be designed and equipped with at least the following control units to be found at all operating mechanisms:

Buttons for manual closing/opening

Control switch for operation mode local / neutral (manual) / remote, with an option of electric block-ing in "neutral" position,

Remotely

Locally, via electric buttons in operating mechanism

Locally, using crank for manual operation.

Blocking

Mechanical and electrical blockings shall ensure to avoid minimum the following conditions:

Concurrent use of closing and opening Contractors

Use of electric motor in the course of manual operation

Electric operation when the crank for manual operation has been inserted.

Activation of main blades when earthing blades are activated and vice versa

Mechanical blocking of the main blades when earthing blades are activated and vice versa

Auxiliary Contacts

Manufacturer shall for each mechanism provide sufficient number of mechanical auxiliary contacts for normal closing and normal opening, number specified in the Technical Data Schedules. The auxiliary contacts shall be Class 1 and shall offer the option of time adjustment.

High-Voltage Terminals

High-voltage terminals shall be:

- **horizontal,**
- **flat,**

for aluminium conductor,
minimum area of 200 or 100 x 100 mm.
with minimum eight or four holes 14 mm diameter, at 50 mm distance between each other.

Metal Structure

The Contractor shall provide and deliver suitable horizontal supporting structure. The horizontal sup- porting structure as well as all other pertinent metal components shall be galvanized with minimum 70µm zinc layer.

Environmental Protection

Design of Disconnectors shall be designed to take maximum care of environment.

Insulators

Insulators shall be made of brown porcelain, according to technical specifications. Any connection be- tween porcelain and flange shall be made with Portland cement. The connection itself shall be han- dled with such manner so as to prevent retaining or intrusion of moisture. Metal parts shall be galva- nized with minimum 70 µm zinc layer.
Minimum creepage distance is 25 mm/kV.

Special Equipment AND Tools

The Contractor is obliged to deliver all equipment and tools required for installation, testing and maintenance of disconnectors. Special equipment and tools shall be of the highest quality and suitable for field work. All materials to be used shall be new.
Special equipment and tools list shall be defined by the Technical data Schedule. Special equipment and tools shall be supplied in a number defined by the Technical data Schedule.
The Employer reserves the right to request any other special equipment or tools during training or test- ing, which he finds necessary, free of charge, although such equipment or tools were not on the list of special equipment.

Spare Parts

Contractor is obliged to enclose with the bid a list of recommended spares required for operation and maintenance of disconnectors.

Packing, Shipment and Transportation

Each disconnector shall be separately packed. It is not allowed to pack parts for more disconnectors in one package. The equipment shall be packed and ready to be stored for a longer period. All operating mechanisms shall be provided and packed so as the heater can be connected. For this purpose pro-vide a suitable cable with a plug.

Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

Type Tests

Refer to volume 01

Routine Test

As per IEC STANDARD

3.4.7 INSTRUMENT TRANSFORMER

This chapter covers the ratings, design, equipment requirements, inspection and testing of the equip-ment. It states only those general aspects that are meant to ensure minimum requirements with re- spect of quality and performance.

Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the rele-vant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specif- ically in the following specifications.

General Design - Current Transformers

The current transformers shall be for outdoor installation, single phase, head type, hermetically sealed, oil-paper immersed. SF6 gas is not allowed. They shall be multi core with appropriate charac- teristics. They shall be designed to allow secondary reconnection. Primary reconnection is not al- lowed.

The current transformers shall be supported by a porcelain insulator. They shall comply with IEC 60044 and shall be equipped with:

Expansion chamber/and internal metal bellows type oil gauge
diaphragm. Device for determining insulating medium level.
Oil drain cock and sampling
device. tgδ measuring connection

Low voltage terminal box

Enable sealing after accuracy class checks (sealing
possibilities). Overpressure device

Adequate earth terminal connection

General Design - Voltage Transformers

The voltage transformers shall be for outdoor installation, single phase, hermetically sealed. Capacitive voltage transformers as insulation medium shall be oil-paper immersed or impregnate-mixed dielectric. Inductive voltage transformers as insulation medium shall be oil-paper immersed, on-ly. SF_6 gas is not allowed.

The tgδ for capacitive divider of capacitive voltage transformers shall not be greater than 0.1%.For ef- ficient suppression of the ferroresonance feature, working induction of intermediate transformer of ca- pacitive voltage transformer should be ≤ 0.5 T.

The voltage transformers shall have multi secondary windings appropriate characteristics. Capacitive voltage transformers should be used as capacitor for HF connection. They shall be supported by porcelain insulator.

The voltage transformers shall comply with IEC 60044. They shall be equipped with:

- **Expansion chamber/and internal metal bellows type oil gauge**
- **diaphragm. Device for determining insulating medium level**
- **Oil drain cock and sampling**
- **device tgδ measuring connection**

Low voltage terminal box

Adequate earth terminal connection

Enable sealing after accuracy class checks (sealing possibilities)

- **terminal connection for anti-ferroresonance control for capacitive voltage**
- **transformers HF connection terminal for capacitive voltage transformers**

Overpressure device

High-Voltage Terminals

High-voltage terminals shall be:

- **horizontal (or vertical, for voltage transformers**
- **only), flat,**

for aluminium conductor,

- **minimum area of 200 or 100 x 100 mm, with eight or four holes, 14 mm diameter, at 50 mm**
- **dis-tance between each other**

Permissible Partial Discharges Level

Instrument transformers should be so designed to have a neglect level of partial discharges. Contrac- tor shall guarantee a partial discharge level lower or equal to maximum allowed according to the IEC standards. It is desirable that partial discharge level should be as lower as it is possible.

Outdoor Insulation

Outdoor insulation of instrument transformers shall consist of porcelain insulator element.

Insulators shall be made of brown porcelain, according to technical specifications. Any connection be- tween porcelain and flange shall be made with Portland cement. The connection itself shall be han- dled with such manner so as to prevent retaining or intrusion of moisture. Metal parts shall be made of aluminium, stainless steel or shall be galvanized with minimum 70 µm zinc layer.

Minimum creepage distance is 25 mm/kV.

Environmental Protection

Design of Instrument transformers shall be designed to take maximum care of environment.

Mechanical Terminal Loads

Instrument transformers shall fulfil at least mechanical requirements of Class II.

Mechanical Protection

Design of instrument transformers shall provide hermetically sealing of active parts. Secondary termi-nal box shall be mechanical protection level min. IP54.

Anticorrosion Protection

All outdoor metal parts shall be made of aluminium, stainless steel or shall be galvanized with mini-mum 70 µm zinc layer. All screws and other connecting material must be made of stainless steel. It is not allowed to use material with anticorrosion protection, except metal support structure, which shall be galvanized with minimum 70 µm zinc layer.

Packing, Shipment and Transport

The Contractor is obliged to arrange for preparation, packing and transport of the equipment. Each in-strument transformer shall be separately packed. Copy of a routine test report shall be submitted to- gether with each piece of instrument transformer.

Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime. Acceptance test will be conducted in accordance with the program of routine tests.

Type Tests of Current Transformers

Refer to volume 01

Routine test

As per IEC STANDARD

Type Test of Inductive Voltage Transformers

Refer to volume 01

Routine Tests

As per IEC STANDARD

Routine Tests - Capacitive Voltage Transformers

Routine Tests

As per IEC STANDARD

Routine Tests - Inductive Voltage Transformers

As per IEC STANDARD

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.7 Surge Arresters

This section covers the ratings, design, equipment requirements, inspection and testing of the equip- ment. It states only those general aspects that are meant to ensure minimum requirements with re- spect of quality and performance. Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the rele-vant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specif- ically in the following specifications.

General Design

Surge arresters will be metal-oxide, gapless, outdoor. Design shall comply with the requirements of IEC 60099 and other relevant standards, if it is not requested in different manner in this specification. Surge arresters be shall be hermetically sealed type, composite housing, on insulating basement and with counter. Insulating basement shall be delivered together with the Surge arresters.

High-Voltage Terminals

High-voltage terminals shall be as it is defined in a technical schedule:

- **Vertical,**
- **Flat,**

For aluminium conductor,

With at least eight or four holes 14 mm diameter, at 50 mm distance between each other

Insulating Basement

Surge arresters shall be equipped with appropriate insulating basement that is part of delivery. They shall be fixed and electrically connected to insulating basement. Earthing shall be fixed and electrically connected to surge arrester directly.

Earthing

Surge arresters will be equipped with appropriate earthing connector.

Surge Arresters Housing

Housing shall be made from silicon and/or composite material in accordance with Technical specifica- tion. The connection itself shall be handled with such manner so as to prevent retaining or intrusion of moisture. Minimum creepage distance is 25 mm/kV.

Environmental Protection

Design of surge arresters shall be designed to take maximum care of environment.

Nameplates

Nameplates should have data written in a English language:

Manufacturer name

Type of surge arrester

Rated voltage of surge arrester Ur

- **Continuous operating voltage of surge arrester**
- **Uc Nominal discharge current of an arrester**
- **(8/20 µs) Rated short circuit current**

Rated frequency
Line discharge class
Number of a unit position in a set (for multi units surge arrester) Mass of surge arrester
Year of production
Serial number

Special Equipment, Tools and Drawings

The Contractor is obliged to deliver all equipment and tools required for installation, dismantling, test-ing and maintenance of equipment. Special equipment and tools shall be of the highest quality and suitable for field work. All materials to be used shall be new. A list of special equipment and tools shall be delivered with the bid. The Employer reserves the right to request any other special equipment or tools during training or testing, which he finds necessary, free of charge, although such equipment or tools were not on the list of special equipment.

Spare Parts

The Contractor is obliged to enclose with the bid a list of recommended spares required for operation and maintenance necessary for 10 years period. All spare parts to be used shall be new. A list of spare parts shall be delivered with a bid.

Packing, Shipment and Transportation

The Contractor is obliged to arrange for preparation, packing and transport of the equipment to the destination point. The equipment shall be packed and ready to be stored for a longer period.

Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

Type Tests

Refer to volume 01

Routine Tests

As per IEC STANDARD

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.8 Post Insulators

This Section covers the ratings, design, equipment requirements, inspection and testing of the equip- ment. It states only those general aspects that are meant to ensure minimum requirements with re- spect of quality and performance. Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the rele-vant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specif- ically in the following specifications.

General Design

Post insulators should be solid core type post insulators, made of porcelain, for outdoor installation in the three phase AC system. The post insulators shall comply with the requirements of following stand- ards: IEC 60273, IEC 60437, 60815, 60672, IEC 60168, EN1562, EN1563, EN ISO 1461 and other relevant standards if it is not required in this Specification.

Post insulators should satisfy the best level of development for this kind of equipment in a field of de-sign, construction and material.

Insulator Material

Insulators should be made of high quality aluminium oxide porcelain. Porcelain material shall fulfil re-quirements of a class C130, which confirms to the standard IEC 60672. Insulators shall be cylindrical with a hard core and metal base. Glazing shall be in brown colour.

RIV

The RIV performance of post insulator styles shall be tested in accordance with the standard IEC60437. If corona rings are necessary to reach a certain RIV level for a single insulator column, the appropriate ones shall be delivered with the insulator column.

Fittings

Fittings shall be made in malleable cast iron according to standard EN1562 or spheroidal graphite cast iron according to standard EN1563. All fittings shall be hot dip galvanized according to standard EN ISO 1461 with a zinc weight of min. 600 g/m2 (min. 85 µm) as average value. Connection method of Support insulators shall be in accordance with standard IEC 60273. Connection holes shall be equally arrange on a circle meaning concentric with eight insulators. Holes in upper and lower part of connec- tion equipment should be in line and so arranged to allow usage of standard screws with six-angle heads.

Cementing

Any connection between porcelain and flange shall be made with Portland cement. The connection it-self shall be handled with such manner so as to prevent retaining or intrusion of moisture by a silicone or any other manner.

Insulation Level

Post insulators should be designed for standard value of lightning impulses voltage according IEC 60071-1. Minimal value for the height depend of lightning impulses voltage in dry, power frequency voltage in wet and switching withstand voltage in wet where it is in accordance with relevant require- ment from coordination insulation point.

Dimensions

Rated dimensions of insulator shall be in accordance with values defined in the Technical Data Schedules, with appropriate tolerances referring to parallelism, eccentric and angle deviation, in ac- cordance with standard IEC 60272. Minimum creepage distance is 25 mm/kV.

Packing, Shipment and Transportation

The Contractor is obliged to arrange for preparation, packing and transport of the equipment to the destination point. The equipment shall be packed and ready to be stored for a longer period.

Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

Routine Tests

As per IEC STANDARD

Type Tests

Refer to volume 01

Routine Tests

As per IEC STANDARD

All documents, tables and rating plates attached to the equipment shall be in English language.

Power Transformers

4.1 Scope

These clauses describe the general technical requirements for power transformers and shall be read in conjunction with the attached GTP, Existing ATR NAMEPLATE,BCT ,FIRE FIGHTING SYSTEM in the document.

Installation, testing and commissioning of power transformers shall be done by the Manufacturer(s)' Engineer(s).

4.2 References

4.2.1 IEC Standards

IEC 60076	Power transformers
IEC 60137	Insulated bushings for ac voltages above 1000V
IEC 60044-2	Voltage transformers
IEC 60044-5	- ditto -
IEC 60214-1	On load tap changers
IEC 60228	Conductors of insulated cables
IEC 62155	Tests on hollow insulators for use in electrical equipment
IEC 60289	Reactors and Earthing Transformers
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60354	Loading guide for oil immersed power transformers
IEC 60422	Supervision and maintenance guide for mineral insulating oils in electrical equipment
IEC 60529	Degrees of protection provided by enclosures
IEC 60551	Determination of transformer and reactor sound levels

4.2.2 British Standards

BS61	Specification for threads for light gauge copper tubes and fittings
BS EN 10220	Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes
BS EN 1092	Circular flanges for pipes, valves and fittings (PN designated)
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
BS EN 10137	Specification for hot rolled quenched and tempered weldable plates

4.2.3 BS European Standards

BS EN 10029 **Specification for tolerances on dimensions, shape and mass for hot rolledsteel plates 3mm thick and above**

4.3 Power Transformers

4.3.1 Types of Transformers and Operating Conditions

General

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076, Parts 1 to 5 inclusive.

Electrical clearances shall not be less than those in the appropriate sections of BS 7354, or as stated in the System Electrical Parameters in Section-1 of Volume 2 of 3, whichever is the greater.

Cooling

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 up to half full load or more 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.

Transformers shall be fitted with at least two coolers or two banks of radiators each capable of dissipating 50 per cent of the losses at continuous maximum rating. They shall be capable of remaining in operation at full load for 20 minutes in the event of failure of blowers associated with one half of coolers or radiators, without the calculated winding hot spot temperature exceeding 140˚C.

Failure of one fan in each group of blowers shall not reduce the continuous maximum rating of the transformer.

Parallel Operation

Transformers supplied against each item shall be designed to operate satisfactorily, one with the oth-er, when operating on the same tap position.

Handling on Site

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 al-so 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 tapings, 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-Part 2.

The overload capability shall be in accordance with IEC 60354.

4.3.3 Electrical Connections

Transformer windings shall be connected in accordance with the IEC 60076 group symbol specified in the Schedule of Requirements.

All electrical connections within windings shall be brazed, 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

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 Require-ments.

Calculations and Tests

Evidence shall be submitted with the Bid 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 bid 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 pre- ferred that this information relates to designs comparable with the transformers offered, but, in the event this is not so, the Engineer reserves the fight to require calculations to prove that the design of transformers offered 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 of the transformers shall be as low as is consistent with transport restrictions, reliability and economic use of materials, shall be as stated in the Schedule B of Particulars and Guarantees.

For the evaluation of the bid as per section 3 (Evaluation and qualification criteria) capitalization cost (Evaluated price of transformer losses) due to transformer guaranteed losses shall be a s p e r V o l u m e0 1

The acceptance of transformers (after Factory Acceptance Test) yielding component losses higher than the guaranteed values shall be governed by either of the following:

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, includ-ing 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.

Component losses in excess of guaranteed values and exceeding the tolerance permitted under IEC 60076 Part 1.

The acceptance or rejection 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 that are either equal to or below the guaranteed values, the Bidder will not be entitled to any premium in respect of reduction in losses be-low the guaranteed values.

4.3.7 Impedance

The value of impedance measured on normal and extreme tappings shall be as stated in the attached nameplate for the power transformer in the document.

4.3.8 Noise

The transformer noise levels shall be measured as a type test and in accordance with IEC 60551. The acceptance level of the transformers shall be as stated in the Schedule of Requirements.

Where the bottom plate of the transformer tank will be in direct contact with the surface of the founda-tion, anti-vibration pads shall be provided under the contract for insertion between the transformer and its foundation.

The anti-vibration mountings shall be of an oil and weather resisting rubber or other approved materi-al, capable of operation at temperatures from minus 10'C to plus 80'C. Due regard shall be given to ir-regularities in the tank underbase and the plinth surface. Anti-vibration mountings for separately mounted coolers, pumps, etc. are not required.

The total unloaded depth of anti-vibration material (excluding load spreading plates) in the mountings shall not exceed 40mm.

When loaded to the same pressure as in service, the anti-vibration mountings shall give, at normal room temperature, a vibration attenuation at 100Hz of not less than 32dB (assuming an infinite ground impedance value).

Representative samples of anti-vibration material for the mountings shall be subjected to sample tests.

4.3.9 Harmonic Suppression

Transformers shall be designed with particular attention to the suppression of harmonic voltages, es-pecially the third, fifth and seventh harmonics, and to minimise the detrimental effects resulting there- from.

4.4 Magnetic Circuit and Windings

4.4.1 Magnetic Circuit

The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths internally or to the earthed clamping structure, and the production of flux components normal to the plane of the laminations. Each lamination shall be insulated with a material stable under the action of pressure and hot oil.

The winding structure and major insulation shall be designed to permit an unobstructed flow of cooling oil through core cooling ducts to ensure efficient core cooling.

With the earthing link removed, the magnetic circuit shall be insulated from all structural parts, and shall be capable of withstanding a test voltage to core bolts and to the frame of 2,000 volts RMS for one minute.

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 den- sity in any part of the magnetic circuit does not exceed 1.9 Tesla.

4.4.3 Windings

Transformer 400 kV and 230 kV star connected windings shall have graded insulation as defined in IEC 60076. For 33kV 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 Require- ments.

The windings shall be located in a manner that will ensure that they remain electromagnetically bal- anced 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 that 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.

4.4.4 Internal Earthing

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.

Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bot-tom main core clamping structure shall be earthed by one or more of the following methods:

- **by connection through vertical tie rods to the top structure;**
- **by direct metal-to-metal contact with the tank base maintained by the weight of the ore and windings;**
- **by connection to the top structure on the same side of the core as the main earth connection to the tank.**

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 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.

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.

Size of Earthing Connections
Main earthing connections shall have a cross-sectional area of not less than 80 sq.mm but connec-tions inserted between laminations may have cross-sectional areas reduced to 20 sq.mm 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 7613 and BS EN 10029. The final coat colour of transformers shall be to Munsell notation N5Y-7/1.

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 base of each tank shall be so designed that it is possible to move the complete transformer unit in any direction without injury when using rollers, plates, or rails.

All joints, other than those that 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.

Where called for in the Schedule A of Requirements, accommodation shall be provided for outdoor weatherproof neutral current transformers.

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 provi-sion for locking with a padlock.

4.5.2 Conservator Tanks, Breathers and AirDryers

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 each 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 location of the conservator tank shall be so arranged that it does not obstruct the passage of high voltage conductors immediately above the transformer.

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.
Each conservator shall be fitted with an air cell that shall be connected to a silica gel regenerative dehydrating breather.

The dehydrating breather of a maintenance-free and self-supervision type shall be mounted on the conservator of the transformer and the tap changers. Silica gel shall be used as a drying agent. It is automatically regenerated by the internal heater element controlled by a microprocessor control unit. The relative humidity of the air flow must be controlled by a humidity sensor. The device should have a service-friendly design: The humidity and temp erature sensor, the silica gel and the PCB shall be replaceable in the field. Alpha-control: The maintenance -free breather shall be equipped with a state-dependent control of the heating process by monitoring the humidity Beta-control: The maintenance-free breather shall be equipped with a self-learning algorithm that enables the regeneration process only when the conservator is exhaling. This algorithm is based on humidity monitoring and the temperature-dependent determination of the most advantageous time to perform heating.
There shall be no moving parts to restrict or redirect the air flow from the desiccant chamber. The use of fans to expel condensed water out of the desiccant chamber is also not permitted. Weight cells are not accepted, as well. The flange of the breather (Conservator piping) must be with rigid metal flanges (Hose/flexible connection won't be accepted). The flanges shall be in accordance with the norm DIN 42562-3. The grade of protection of the device shall be IP66/67.

4.5.3 Valves

Each transformer shall be fitted with the following valves as a minimum requirement and inconjuction of the attached required valve schedule.

Main Tank

One 50mm bore filter valve located near to the top of the tank.

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).

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 pro- vided with an approved oil sampling device.

One valve between the main tank and gas actuated relay, complete with bypass facility to facili-tate removal of relay and maintain oil flow.

Conservator

One valve between the conservator and gas actuated relay for the main tank and, where appro-priate, for the tap change diverter switch tank complete with bypass pipework for Buchholz relay to facilitate maintenance of the relay.

One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer

50mm filter and 50mm drain valve where selector switches are contained in a separate tank.

Diverter Switch

One drain valve to be fitted to each tank.

Radiators and Cooler Banks

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 an oil pipework 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 Engineer 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 compres-sion.

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 pres-sure called for in Section 15, shall be provided. It shall be of the spring operated valve type ("Qualitrol" or equivalent) and shall be provided with one set of normally open signalling contacts that 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. Means shall be provided to direct the oil dis-charge to the oil collecting pit.

4.5.6 Earthing Terminals

Two substantial steel flag type terminals each 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 av- erage height of 1500mm above the ground level:-

A rating plate bearing the data specified in IEC 60076 Part 1. This plate shall also include the short-circuit current rating and time-factor for each winding.

A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 60076 Part I with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct phys- ical relationship of the terminals.

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.

4.6 Cooling Plant

4.6.1 Cooling Plant General

Radiators and coolers shall be hot-dip galvanised, designed so that all painted surfaces can be thor- oughly 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 15 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 valve at each point of connection to the tank.**
- **A valve at each point of connection of radiators.**
- **Loose blanking plates for blanking off the main oil connections.**
- **A 50mm filter valve at the top of each cooler bank.**
- **A 50mm drain valve at the lowest point of each interconnecting oil pipe.**
- **A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.**
- **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 inter-changeable, 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 com-ply 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 EN 1092.

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 galvanised steel of thickness not less than 2.6mm (14 S.W.G.) and shall be suitably stiffened by angles or tees.

Galvanised wire guards with mesh not exceeding 12.5mm shall be provided to prevent accidental con- tact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts cannot 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 cool-ing 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 au- tomatic starting and stopping from contacts on the winding temperature indicating devices as speci- fied. 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 totalling more than 15kW simultaneously, either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts that may require periodic renewal, adjustment or inspection shall be readi-ly accessible.

All wiring for the control gear accommodated in the marshalling kiosk, together with all necessary ca-ble boxes and terminations and all wiring between the marshalling kiosk and the motors, shall be in- cluded 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 shall utilise voltage derived from the 400V, 3 phase, 4 wire system. Phase failure relays shall be provided to ensure a secure supply.

Winding taps as called for in the Schedule A of Requirements shall be provided on the high voltage winding.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables con- nected 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

General

On-load tap changers shall be from MR Germany/Hitachi sweden make, comply with IEC 60214-1 and shall be suitable for power flow in both directions. Details are referred to attached GTP & Nameplate in the document.Only de- signs that have been type- tested in accordance with these standards will be accepted. Tap changers in auto-transformers shall be located between the HV and LV windings. The OLTC shall be installed inside the main tank.

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 com- pletely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, de- tection 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.

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 auxil-iary supply during tap change or any other contingency would result in that movement not being com-pleted an approved means shall be provided to safeguard the transformer and its auxiliary equipment. The driving motor shall be rated 400/230V ac and shall be equipped with thermal and over load pro-tection located in the motor drive cubicle. Proper working of the drive motor shall be ensured up to 25% below the rated voltage.

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 pre- vent 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.

Local and Remote Control

Equipment for local manual and electrical operation shall be provided in an outdoor 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 - Schedule of Requirements. The following operating conditions are to apply to the on-load tap changer controls:

It must not be possible to operate the electric drive when the manual operating gear is in use.

It must not be possible for two electric control points to be in operation at the same time.

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.

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)

All electrical control switches and local manual operating gear shall be clearly labelled in an ap-proved manner to indicate the direction of tap changing, i.e. raise and lower tap number.

Emergency stop push-button at local and remote control positions.

Indications

Apparatus of an approved type shall be provided on each transformer:

To give indication mechanically at the transformer and electrically at the remote control point of the number of the tapping in use.

To give electrical indication, separate from that specified above, of tap position at the remote supervisory point.

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.

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.

To indicate at the tap change mechanism the number of operations completed by the equip-ment.

Oil Treatment

Each tap changer is to be equipped with a stationary on-line oil filter facility, complete with time switch control in case of oil type switches used.

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.

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 trans-formers.

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 con-trol 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 60044-5 (for capacitive) IEC 60044-2 (for inductive) 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 refer-ence 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 cir-cuit 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.

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. 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 trans- former and remote control panels as shown on the Specification drawings.

4.7.6 Off-Load Tap Changers(not require)

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.

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.

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 sock- et on the transformer tank against the spring pressure.

Tap-position numbers corresponding to the tapping switch bolt-locating sockets shall be cast or en- graved 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 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 in- creases.

4.8 Supervisory Control

4.8.1 Requirements

Transformer tap change control will be effected from the substation control room with facilities for re-mote control from the load despatch centre. All necessary connections, indications, auxiliary switches, relays and changeover switches to meet supervisory control requirements shall be provided and con- nected 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:

- **Supervisory selection of auto/non-auto voltage control.**
- **Tap change raise/lower by direct operation of tap changer.**
- **Tap change blocking on/off.**
- **Remote/supervisory selection "override".**
- **Parallel/independent control.**

Indications and Alarms:

- **Tap position indication by means of transducer with 4-20 mA d.c. output range proportional to step increment.**
- **Tap change out of step alarm.**
- **Buchholz and winding temperature non-trip alarm.**
- **Tap change control on Local/Supervisory.**
- **Parallel/independent, master/follower.**
- **Tap change blocking on/off.**
- **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 General

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. The current rating of each bushing shall be equal to or greater than the current it will carry at the maximum forced-cooled rating and overload rating. Additionally, the current rating of each neutral bushing shall not be less than the current rating of the associ ated line bushings. The bushing, when required, shall be rated to sustain the maximum operating current of the common winding. Bushing leads shall be accessible from the bushing cover. Accessibility to leads shall not require personnel to enter the transformer tank. draw-lead connection is required for all bushings whenever possible. In cases where the transformer winding leads are bolted to the bottom of the bushings, two-bolt connections shall be used; single-bolt connections are not acceptable. Approved suppliers of bushings are: HITACHI (Sweden), Trench (France/USA), HSP (Germany), GE (Italy)

4.9.2 Porcelain

Hollow porcelain shall meet the test requirements of IEC 60233 and shall be sound, free from defects and thoroughly verified. Designs based on jointed porcelains will not be acceptable. The glaze must not be depended upon for insulation. The glaze shall be smooth, hard, of a uniform shade of brown and shall cover completely all exposed parts of the insulator. Outdoor insulators and fittings shall be unaffected by atmospheric conditions producing weathering, acids, alkalis, dust and rapid changes in temperature that may be experienced under working conditions.

The porcelain must not engage directly with hard metal and, where necessary, gaskets shall be inter- posed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

All fixing material used shall be of suitable quality and properly applied and must not enter into chemi-

cal action with the metal parts or cause fracture by expansion in service. Cement thicknesses are to be as small and even as possible and proper care is to be taken to centre and locate the individual parts correctly during cementing.

All porcelain insulators shall be designed to facilitate cleaning.

4.9.3 Marking

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 im- printed before firing, not impressed.

When a batch of insulators bearing a certain identification mark has been rejected, no further insula-tors bearing this mark shall be submitted and the Contractor shall satisfy the Engineer that adequate steps will be taken to mark or segregate the insulators constituting the rejected batch in such a way that there can be no possibility of the insulators being re-submitted for the test or supplied for the use of the Employer.

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.

4.9.4 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 trans- former tank. The current transformer will be supplied by the switchgear Manufacturer but provision shall be made on the tank for mounting to the Engineer's requirements.

The clearances from phase to earth must not be less than those stated in the Schedule A of Require- ments.

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 that 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 that may trap air.

Clamps and fittings made of steel or malleable iron shall be galvanised and all bolt threads are to be greased before erection.

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 Contractor 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 utilise compression glands of type El to BS.6121 or other- wise 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 Contractor shall supply and fit the compression gland and make off individual cores on to the ter- minal 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 de- vice shall have four separate contacts fitted, two of which shall be used to control the two groups of cooling plant motors (i.e. AF1 and AF2), 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 con- tacts 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 5˚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 5˚C and 10˚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 moving iron ammeter shall be provided in the marshalling kiosk for each WTI for:

Checking the output of the current transformer.
Testing the current transformer and thermal image characteristics.
Disconnecting the bulb heaters from the current transformer secondary circuit to enable the in-strument 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 that close on collection of gas or low oil level, and tripping contacts that close following oil surge condi- tions.

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 mal-operation 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 operat-ing 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 cir-culating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipework shall be avoided.

When a transformer is provided with two conservators, the gas and oil-actuated relays shall be ar-ranged as follows:

If the two conservators are connected to the transformer by a common oil pipe, one relay shall be installed in the common pipe.

If the two conservators are piped separately to the transformer, two relays shall be installed, one in each pipe connection.

The clearance between oil pipework and live metal shall be not less than the minimum clearances stated in the Project Requirements of Section 1.

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 that 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.

All earthing transformers shall be shipped full of oil.

4.12.2 Drying Out

All transformers shall be dried out by an approved method at the Manufacturer's works and so ar- ranged 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 precaution- ary 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 trans- former to withstand the treatment shall be provided with each

transformer.

4.12.3 Fire Protection System

4.12.3.1 General

The new 420/245/36kV, 750/750/150 MVA, ONAN/ONAF autotransformers shall be provided with water spray system.Existing water spray system drawing is attached in the document . Bidder have to consider this for the adaptation with the transformer. Existing water spray system already connected for ATR1 &ATR2 .System shall be extended for the ATR3 .

The Contractor shall provide the water spray system arrangements specified below:

The water spray system shall be provided with a valve station including the necessary control and monitoring cabinet to be capable of extension to serve in total four transformer units.

The water spray system is 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 nozzle pipe network.The necessary drainage valves, struts, diaphragm sleeve valves, single

chamber valve stations with all fittings and connections, pressure-sensitive switches for signaling and air pressure drop, with the possibility of extension by four transformers

The necessary tank feed pump
Pressurizing air vessel for maintaining a reserve of fire-fighting water

The required water discharge rate shall be 10litter / m^2 / min. Design wind velocity shall be 10m / sec. The required water volume shall be considered for spraying for any one unit of the power transformers.

The pressurizing air vessel is to be designed for a minimum spraying time of 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
1 415/240V three-phase motor
1 flexible coupling
1 oil and water separator
1 non-return valve
1 vent and drain valve
1 pressure gauge

Installed completely on a sturdy base frame with all necessary anti-vibration mounts and fixing material.

One compressed air container, 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 IP55, completely equipped with the following main items:

2 motor protection switches, 415/240V, 50Hz, coil voltage 240V 50Hz / 110Vdc, auxiliary contactors and relays for optional operation of compressors

1 and 2 with switch controlling operation

With terminal board and cable entry glands as well as the necessary local fault and indicator lamps and spare contacts for remote 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 shall be provided for the compressed air distribution.

4.12.3.2 TESTING

Inspection and testing of transformers during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.

4.13 Fire Wall

A fire wall of suitable height shall be installed between the transformers to prevent transformers from the spread fire. The wall shall be made of reinforced concrete.

4.13 Transformer Oil and Treatment

4.13.1 Transformer Oil

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. The Con- tractor 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.

4.14 Fiber Optic Based Temperature Sensing System

4.14.1 Fiber optic based direct temperature sensing shall be provided for power transformer winding. The purpose is to provide for faster and more appropriate response to sudden load increases. Hot spot temperature shall also be measured with the help of fiber optic sensors. Instead of one point of measurement, multiple point of measurement shall be used for more accurate result. The probe shall be distributed evenly & suitably to have comprehensive results. Probes shall be such designed and inserted so that winding insulation is not compromised. Typically, 2 probes will be mounted at the hot spot location in each phase. The Fiber Optic Based Temperature Sensing System will be incorporated mainly for the voltage levels of 230 kV & above.

4.14.2 The winding sensors are typically located at:

- **Near top of upper primary oil duct, X-winding -- 2/ph**
- **Near bottom of lower primary oil duct, Y-winding--- 2/ph**
- **Near bottom of lower primary oil duct, Z-winding--- 2/ph when applicable One (Total 03) more on each core legs**

4.14.3 Sensors located other than specified locations which are well adopted in the industry shall be deemed to finalized during detail design prior to Employers approval.

4.14.4 Design having one probe in the lateral phases (A/C) is acceptable subject to justification that, such design is reliable and does not affect the performance considering the sensors life-time.

4.14.5 Design of Fiber optic probe must be robust. Ideally, long-life probes should have the following characteristics:

- **The sensing technology must be absolutely stable with time, immersed in harsh chemical environments, and at elevated temperatures**
- **The probes must be designed so they can mechanically survive steady vibrations and frequent thermal cycles inside the power transformer.**
- **The technology that converts the light signal into temperature information must be insensitive to light intensity variations. This is required to avoid problematic compensation for any aging effects in the optical fiber link and any interconnections**
- **Fiber connectors must be leak-proof, reliable and maintenance-free. Oil in optical path should not**

interfere with signal.

4.14.6 Although it may seem more accurate to mount fiber optic probes directly on the conductors, however, it can also be mounted in radial spacers. Also, it appears that the temperature under the spacer is higher by 1 or 2°C than the surrounding conductor. Hence, the manufacturer must take approval from the employer during design approval about the place of mounting of fiber optic probes.

4.14.7 The HMI for temperature monitoring shall be of modular type and shall be mounted in the RTCC panel of transformer with IP54. However, transformer body mounted module is also acceptable with higher IP (i.e. IP66) EMC rating. Operating temperature shall be -200C to +550C. All accessories like Fiber optic cables, couplers, RS-485 port etc. shall be provided. Approved communication protocols are IEC 61850, shall be used in the system. Serial or TCP/IP communication shall also be available. SCADA integration option shall be made available. Any software (if required) shall be furnished. Spare items like light source, probes etc. vulnerable parts shall be supplied with sufficient numbers along with the system. Light source shall have a minimum MTBF of 300 years. Calibrated accuracy shall be of ± 01°C

4.13.2 Oil Treatment Plant

oil treatment plant for the treatment of insulating oil for the initial filling of transformers at Site and handed over the same to Employer at the end of work.

The oil treatment plant is to be mounted on a steerable trailer equipped with pneumatic types, over-run and parking brakes and weatherproof canopy. The plant shall be capable of treatment of oil to IEC 60296 and IEC 60422, shall be of the replaceable paper filter type and shall have the following facili- ties:

Oil treatment rate as requred
Water extraction capability down to 5 ppm.
Reduction of dissolved gas content to 1% by volume or less.
Filtration level less than 1 micron.
Oil transfer, vacuum pumps and heaters suitable for 40OV, 3 phase 50Hz, 4 wire, supply.
Vacuum capability approximately 1 Torr.
Facility to apply vacuum to transformer tank during oil filling.
Two 15m lengths of wire reinforced hose coloured differently for clean and dirty oil.
Facility for "closed loop" operation.
One 20m length of power supply cable with plug and socket at the filter end only.

4.13.3 Oil Storage

As required by Clause 4.13. 1, the Contractor shall supply the first filling of transformer oil. It is envis- aged that the oil will be supplied to site in 200kg drums and filtered by use of the plant described in the preceding paragraph into a storage tank prior to transfer again via filter plant into the transformer.

Storage tanks shall be painted internally and externally and shall be equipped with:

50mm top inlet and bottom outlets with blank
flanges. 50mm drain valve.
Oil level indicator.
Manhole.
Silica gel breather.

4.14 Earthing/Auxiliary Transformers(not require)

4.14.1 General

Earthing transformers shall comply with IEC 60289 and shall be of the oil immersed ONAN type suita-ble for outdoor installation. They are to have a main interconnected star winding 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 33/0.415kV. 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 200kVA 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, provi- sion 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 2 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/mm².

In addition, the interconnected star winding of each earthing transformer, when at its maximum tem-perature 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 den-sity under such conditions shall not exceed 23A/mm².

4.14.3 Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

Conservator vessel with removable end cover and prismatic oil gauge.
Buchholz relay.
One thermometer pocket with captive screw cap.
Silica gel breather of the oil seal type with a minimum capacity of 1 kg.
Pressure relief device.
Filter valve and combined filter and drain valves.
Oil sampling device.
Rating plate.
Tank earth terminals.
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 400V 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 shall be via a 33 kV conductor.

4.15 Testing

Tests shall be carried out in order to determine whether the material and equipment complies with the required properties. All tests on materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime. Test shall be performed at all power transformers.

4.15.1 Factory Acceptance Tests

Factory Acceptance test shall be conducted in the Manufacturer's laboratory, in presence of nominated representatives(02) of the Employer, before delivery for 11(Eleven) days excluding travel time. All costs including visa fee, health insurance, transport, accommodation, food, daily allowance as well as costs for the tests shall be borne by the Contractor and included in the contract price.

Acceptance test will be conducted in accordance with the program of Routine tests.

Type Tests

Refer to volume 01

Routine Tests

AS per IEC standard

4.15.2 Site Tests

Tests During Installation

The following tests shall be performed during and after installation on the entire equipment in order to ensure correct assembly of the equipment as well as to prove that the equipment has been correctly installed:

Verification of proper and complete erection

Verification of the proper condition of porcelains, sealing and external surfaces Verification of proper connection to the earthing system

Verification of transformer bolted connections by torque spanner Voltage tests of all electrical LV circuits

Verification of the proper cabling and operation of all electrical LV equipment Verification of control and protection circuits and wiring.

Commissioning Tests

Main objective of the commissioning tests is to check proper and safe operation of the equipment, and in particular to verify and confirm the factory acceptance test results.

The following commissioning tests will be performed before putting the transformers into operation:

Measurements of insulation resistances of windings and magnetic core. Capacitance (C), dielectric losses (tgδ) and winding inductance.

Measurement of winding resistance at all tap changer positions.

Measurement of voltage ratio at all tap changer positions and check of winding connection.

Operation test of all protection units, measuring and alarm (signalling) units, Buchholz relay, con- tact thermometer, thermal image unit, etc.

Operation test of cooling-system controls and alarms.

Operation test of tap changer controls and alarms. SFRA

DIRANA

Di-electric Response analysis

Oil dielectric strength.
Physical, chemical and electrical characteristics of oil.

4.16 TRANSFORMER MONITORING SYSTEM from EU

In order to monitor the status of the transformer on-line monitoring system is required. The system shall be compatible with IEC -61850 communication protocol in the substation automation system. The collected operational data shall be transferred to the independent control server and HMI system. The system shall be supplied with engineering software. Items required to be monitored are as stated in the table below, and additions of items shall be proposed by transformer manufacturer if necessary for reliable and stable monitoring:

Categories	Items
Temperature	Top Oil Ambient Winding Hot Spot Temperature

Cooling System	Fan (or Pump) failure Cooling contact Failure
On-Load Tap Changer	Tap position Tap counter
Core & Coil	Dissolved Gas and moisture

The transformer Manufacturer shall provide On-line Dissolved Gas monitoring System for the proposed transformer having vacuum gas extraction module ,spectral scanning principle with IP66 Housing. Gas elements monitored and its detection precision shall satisfy the following table. The Contractor shall furnish the supply record of On-line Gas monitoring System issued by the proposed manufacturer .

Gas element to be monitored	Detection Limit
acetylene (C2H2)	0.5 – 500 ppm
hydrogen (H2)	20 – 2000 ppm
methane (CH4)	20 – 2000 ppm
carbon monoxide (CO)	20 – 2000 ppm
ethylene (C2H4)	10 – 2000 ppm
ethane (C2H6)	20 – 2000 ppm
moisture content	0 – 1000 ppm
Co_2	20-30000ppm
O_2	500-25000ppm

Protection, Metering and Control

5.1 General

This specification covers the, setting, parameterisation and architecture configuration, field testing, commissioning, warranty and lifetime support of 400/230/33kV substation automation system including protection, metering and control in- cluded in the contract works.

Relay panels are available with protective relays within the guide line of Grid code.protection systems, schematic are to be tested and commission under this scope for ATR _BAY by OEM Engr. Or their certified Engineer.

Testing of protection functions, including the full schemes involving control, communication, supervi-sion, etc., shall be performed at the site.

The protection, metering and control facilities shall be suitable for the power system arrangement as shown on the bid drawings.

From operational experience, including -system stability, protection condition, integration with existing protection and control equipment, capitalizing of staff experience and familiarization with equipment, protection settings calculation mechanism and methodology of operation, standardization of operation performance, facilities and spare requirements, the protection relays, control & automation systems in- cluding complete panel are being rationalized to specific types. The system operator is making every effort to ensure smooth operation and better reliability of the system and to avoid serious system mal- functioning. For standardisation 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, GE (USA/UK), SEL (USA/UK/Canada), Siemens (Germany)

All relays shall operate correctly within system frequency limits of 47Hz to 51Hz.

testing and Commissioning of Control, protection and metering system shall be done by OEM Engr or OEM certified Engineer.

5.2

kV, 230 kV and 33 kV systems' overall fault clearance times (i.e. from fault initiation to arc extinc-tion) shall not exceed the following:

Type of Fault	Maximum Fault Clearance Time			
Nominal system voltage between phases	kV	400	230	33
Substation and transformer fault	msec.	80	100	160
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	160
72% of 100% of the line length where (@) plus protection signalling time	msec.	100	130	190

5.3 Cubicles, Panels and Wiring

All cubicles and enclosures with their auxiliaries described in this specification are intended for contin- uous duty at the specified ratings under the climatic conditions prevailing at the location where the rel- evant equipment will be installed.

5.3.1 Terminal Blocks

All internal wiring to be connected to the external equipment shall terminate on terminal blocks con- sisting of a clamping yoke system, preferably vertically mounted on the side of the cubicle.

The terminal block design shall be such that various types and sizes can be mounted on TS 35 rails to profile details in DIN 46277/EN. The surface protection of the mounting rail has to be zink plated and

yellow cremated. Each individual block design shall have a foot design that ensures a secure fit on the rail and allows removal of individual terminals from the centre of an assembly.

The moulding design shall ensure that all metal parts are shrouded to meet the requirements of the IEC finger test (finger-safe) and to BS 3042 without the need for additional covers.

The rated current of the terminal blocks shall be according to DIN VDE 0611-1 with reference to the rated cross-sections. The current bar shall be of a suitable electrical conducting material like cop-per /alloy or copper plated with tin lead combination to guarantee the best connection between the conductor and the current bar. The current bar shall be designed to retain high clamping pressure.
The rated voltage of the terminal block shall be based on the insulation tests and creepage distances according to VDE 0110-1.

The terminals shall be such that the maximum contact area is achieved when a cable is terminated.The terminal shall have locking characteristics to prevent cable from escaping from the terminal clamp unless it is done intentionally.

The terminal blocks shall be feed through clamping yoke type.

The terminal blocks shall be extendible design.

The terminal blocks shall have a self-locking arrangement to prevent its escape from the mounting rails.

The terminal blocks shall be fully enclosed with removable covers of transparent, non-inflammable, non-deteriorating type plastic material.Insulating barriers Partition plate? shall be provided between the terminal blocks.These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

The terminals shall be provided with the marking tags for wiring identification on both sides.

The arrangements shall be such that it is possible to safely connect or disconnect terminals on live cir- cuits and replace fuse links when the cabinet is live.

Terminal blocks shall be numbered consecutively, preferably beginning with 1, from left to right or top to bottom.

All terminals shall have two separate pressure clamping points suitable for connection of incoming or outgoing stranded or solid conductors, respectively, however only one wire per terminal will be accepted. Terminals with clamping screws in direct contact with the conductor and soldering are not acceptable. If stranded or fine stranded wire are in use the wire-end have to be prepared with wire-end-ferrules made from copper und has to be crimped on the wire according DIN 46228 T 1 & T 4.

The following minimum categories of terminals shall be used:

Terminals for power circuits of 10 mm², 6 mm² and 2.5 mm² wire size

Terminals utilised in the secondary circuit of CTs (4mm² wire size), VTs and measuring transducers shall be supplied with a terminal with the following characteristics:

- **sliding link disconnect function**
- **cross connecting disconnecting facilities**
- **short circuit facilities for CT and instruments**

– two integrated test sockets for test instruments per terminal, colored yellow, green & lilac
– it shall be possible to cross-connect the K-point of the CT by a fixed cross connecting link on the terminal, not by a wire link. A locking mechanism shall be included.

Terminals for wiring of 1.5 mm² and 0.5 mm² wire size with bridging facilities to the neighbouring terminals.

Terminal blocks for protective conductors shall be designed to pollution severity category 3, rated to DIN VDE 0110-1, VDE 0611, part 3 and IEC 60947-7-2 and coloured green/yellow. They shall be fixed onto the mounting rail by means of a separate screw and clamping foot mechanism or by independ- ent, self-locking metal foot clamping directly onto the assembly rail and shall have the ability to be ar- ranged in the relevant sequences to match the phase circuits.

5.3.2 Labels

The boards shall be clearly labelled with the name of the circuit on the front, at the rear and inside the board.
All labels shall be in English.

Each relay and electronic card in the board shall be identified by labels fixed permanently to the board next to the equipment concerned. If the equipment is connected to a terminal and to a socket, the ter- minal and the socket shall have permanent identification labels.

The labels shall be solidly fixed using screws. The use of adhesive tape to fix labels will not be ac- ceptable.

5.3.3 Miscellaneous Accessories

Plug Point
240V, single phase 50Hz, AC socket shall be provided in the interior of each cubicle with ON-OFF switch.

Interior Lighting
Each panel shall be provided with a fluorescent lighting fixture rated for 240 V, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch.

Space Heater
Each panel shall be provided with a thermostatically connected space heater rated for 240V, single phase, 50Hz AC supply for the internal heating of the panel to prevent condensation of moisture.

5.3.4 Earthing

All panels shall be equipped with an earthbus securely fixed. The material and sizes of the busbar shall be at least 25x6 mm² copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc. for effective earthing. When sev- eral panels are mounted adjoining each other, the earth bus shall be made continuous, and necessary connectors and clamps for this purpose shall be provided. Provision shall be made for extending the earth busbars to future adjoining panels on either side.

All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by yellow/green copper wire of not less than 2.5 mm².

5.3.5 Testing Facilities

Software for testing the protection and 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.

5.4 Relays and Scheme

5.4.1 General

.

Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case. Relays and BCPU to be supplied shall be fully complied with attached PSLD.

Relay contacts shall be suitable for making and breaking the maximum currents that 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.

Relays, where appropriate, shall be provided with LED or flag indicators, phase coloured where appli- cable. 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 in- dicators shall be provided for each element.

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.

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.

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.

Any auxiliary supplies needed shall be drawn from the main station batteries and not from separate in-ternal batteries in the protection equipment.

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.

Attention is practically drawn to the tropical climate and relay designs should be entirely suitable for duty under full tropical conditions.

To minimise the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energised from the positive pole of the battery.

Relay shall be suitable for operation on 110 V nominal, 121 V float DC systems without the use of voltage dropping resistors or diodes. Relay required for 220v dc shall be installed accordingly.

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.

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.

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 utilise 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.

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.

5.4.2 Scheme

Schemes are defined through psld and trip matrix. Shall be tested during commissioning.

5.4.2.1 Trip Relays

Trip relays shall be incorporated according to the scheme.

5.4.2.2 Trip Circuit Supervision

Trip circuit supervision relays shall be incorporated according to the scheme.

5.4.2.3 Protection Supply Supervision Relays

system as per CRP scheme shall be tested and rectified.

5.4.2.4 VT Supervision Relays

Existing system as per CRP scheme shall be tested and rectified.

5.4.3 Overhead Line Protection
230 kV Transmission Line Protection

The 230 kV overhead transmission lines shall be protected by a full scheme of differential protective relays with distance relays with PUTT/POTT scheme as a Main 1, and by another full scheme of differential with distance relays with PUTT/POTT scheme as a Main 2. Directional overcurrent and earthfault protection shall be provided as back-up. Protective devices for Main 1 and Main 2 overhead line protection are shown in the bid drawings. These devices shall comply with the following:

Two stages overvoltage protection shall be provided for 230kV lines. The O/V protection relays shall have a high drop-off to pickup ratio with adjustable setting range for voltage and time. The low set stage shall monitor any phase-to-phase voltage and shall have an associated timer. The high set stage shall monitor all three phase-to-phase voltages and shall have an associated timer. This shall be connected to trip the concerned line breakers, to start local breaker back-up, to block auto- reclosure and to send direct trip commands. . Each set of protection will be energised from sepa- rate 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 con- tacts used for initiation of auto reclosing shall have the same dwell time as the main tripping con- tacts to avoid any problems arising from

contact racing with the auto reclose relay.

. 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.Both end relay of the line shall be the same .for Main1 and Main2 with different manufacturer or same manufacturer with different model.

5.4.4 Distance and Directional Earthfault Protection

Distance protection shall comprise at least duplicate three-zone distance relays capable of detecting all types of phase and earth faults.

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.

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.

The Zone 3 elements shall provide a further time delayed back-up zone.

The relay scheme offered shall be suitable for use in the permissive under-reaching, permissive over-reaching, blocking and unblocking modes. 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 or short overhead lines or cables, double circuit lines, heavily loaded lines, lines with weak infeeds etc.

The permissive overreach scheme shall operate in a permissive underreach/overreach transfer trip-ping mode with underreaching zone I elements and overreaching zone 2 elements and suitable logic to achieve fast tripping at the sending end in the event of a weak infeed at the receiving end. The weak infeed logic shall comprise a zone 3 element set to look in the reverse direction, which "echoes" back the received signal to the sending end if the reversed zone 3 comparator does not operate.

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.

Distance protection back-up zones shall also trip the remote end circuit breaker(s) via a direct inter- tripping channel.

Partially cross polarised 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 char-acteristics 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. 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 in-dependently off set in both directions.

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.

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.

Single pole tripping and auto-reclosing are being employed and the auto-reclosing scheme require- ments 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 calcula- tions.

Auto reclosing shall be capable of being blocked for

- **any three phase fault**
- **any Zone 2 or Zone 3 time delayed trip**
- **carrier channel out of service**
- **DEF aided trip**
- **DEF back up time delayed trip**
- **Switch on to fault.**

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.

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.

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.

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 cur- rent.

Under no circumstances shall any line protection operate because of normal system switching includ-ing de-energisation of the line.

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.

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.

A carrier receive 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.

A monitoring system shall be provided to supervise the voltage transformer supply to each set of dis- tance 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.

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.

Directional earth fault protection operating in a permissive overreach scheme shall be provided to ca-ter for high resistance faults which cannot be detected by the distance protection. The same telepro- tection signalling channel shall be used for the directional earth fault scheme and the distance protec- tion scheme. An echo feature shall be included with the DEF Scheme and shall be subject to approval by the Engineer.

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 appreci- ated 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.

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 fol-lowing operation of a DEF aided trip shall be selectable by means of a switch.

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.

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.
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.

The distance protection time delayed back-up Zones 2 and 3 and the directional earth fault back-up stage shall intertrip the remote station circuit breakers over direct intertripping channels.

Auto reclosing shall not be initiated on receipt of direct intertripping signal. Direct intertripping shall al-so be initiated in the event of a 3 phase fault in any zone, or following a switch on to fault trip.

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.

Facilities shall be provided to block zones 1, 2 and 3 of the distance relay from the power swing block-ing logic as required.

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.

The associated time delay relay shall have a setting range of 50-250 ms.

Relays shall be of numerical design. Electromechanical relays will not be accepted. The Numerical re- lays 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 pro- vided 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 possi- ble to do the settings off line and load the settings on to the relay with a standard portable PC. A sepa- rate 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.

Reset times shall be low to ensure the associated distance relay reverts to its normal role as soon as possible following a power swing.

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.

If the associated VT supplies are lost due to VT fuse failure the power swing blocking relay shall not operate.

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.

Detailed relay setting calculations shall be furnished and submitted for approval. It is the Contractor's responsibility to compile all required data for setting calculations in close coordination with PGCB. Final setting tables shall be prepared and the relays shall be configured accordingly. All settings available in the protection with set values shall be available in the setting table. All reference datasheets used for setting calculations shall be attached to the setting calculations.

5.4.5 Directional Overcurrent and Earth Fault Protection

The overcurrent and earth fault relays shall be fully numerical and shall have multi characteristics (in- verse, very inverse, extremely inverse) to IEC 60255.

Overcurrent relays shall have a current setting range from at least 50% to 200% in 25% setting steps.

Earth fault relays shall have a current setting range from at least 20% to 80% in 10% setting steps.

Time multiplier settings shall be continuously adjustable from 0 to 1 or, as an alternative, in steps of 0.025 from 0.05 to 1.0.

Transformer circuits relays shall be provided with high-set instantaneous units which can be set to 1.25 times the fault current in the HV winding for a fault on the LV terminals computed using the trans-former minimum impedance and assuming negligible source impedance. The instantaneous unit shall have low transient overreach (less than 5% for system X/R ratio of 10) and an operating time of less than 40 msec. at two times the current setting.

Line circuit 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.

Overcurrent and earth fault relays shall trip via the CB duplicate trip coils and shall initiate duplicated direct intertripping to the remote line end CB.

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 with-

stand time of the relay. The Bidder shall provide copies of type test reports to show that this require-ment is met.

Where directional back-up overcurrent and earth fault devices are specified, directional elements shall be voltage-polarised.

Directional units for directional overcurrent protection shall be quadrature-connected with a relay char-acteristic angle setting of 30˚ or 45˚ current leading voltage.

Directional units for directional earth fault back-up protection shall employ residual voltage quantities, and the relay characteristic angle shall be variable 0˚, 45˚ and 60˚, current lag.

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.

The relay shall be capable of operating correctly when both the operating current and polarising volt-age quantities are 1% of rated values at an angle equal to the relay characteristic angle.

The residual polarising voltage for earth faults may reach 190.5 volts; therefore it should withstand this value continuously. The continuous withstand current should be no less than twice rated current.

5.5 Busbar Protection

5.5.1 Busbar Protection

The busbar protection have the following features:

Two independent measurement & tripping criteria. 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 condi- tions. They shall meet the fault clearance time of 80 ms under all conditions.

Two independent hand or electrically reset busbar protection trip relays shall be associated with each circuit breaker. These trip relays may also be employed for circuit breaker failure. Opera- tion of either of these relays shall block closing of the associated circuit breaker.

Each trip relay shall trip the circuit breaker via both trip coils. Both relays on the 220 kV trans- former circuits shall trip the associated circuit breakers.

The operating time of the measuring relays shall not exceed 30 msec. at five times the relay current setting.

Continuous supervision of CT secondary against any possible open circuit; if it occurs, it shall render the relevant protection zone inoperative and shall initiate an alarm.

The busbar protection will be supplied from multi-ratio current transformers. The working ratio will be selected on the basis of maximum load transfer in the same manner as the line current transformer ra- tios.

The overall fault setting shall be between 10% and 30% of the minimum fault current available for any type of fault, unless otherwise specified. The minimum fault current for 230 kV busbar faults will be ad- vised at a later stage.

The rated stability limit of the protection shall not be less than the switchgear short circuit rating.

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 current transformer supervision equipment should take the defective protection zone out-of-service.

The contract shall include for all necessary current transformers, relay panels, marshalling boxes, iso- lating and shorting links, etc. A lockable busbar protection ON/OFF switch shall be provided. Lockable maintenance switches shall be provided for each bay unit of busbar protection.
Test terminal blocks to be provided shall be fully enclosed with removable covers. All terminals shall be clearly marked with identification numbers. Test terminal blocks shall have shorting, disconnecting and testing facilities for CT circuits.

Current transformer secondary bus wiring should be suitably dimensioned to reduce current trans-former burdens to a minimum.

Suitable voltage limiting devices shall be provided as necessary, including across the unused part of the CT secondary when tappings are employed.

Full details of the scheme offered, together with performance figures for stability and sensitivity, shall be provided in accordance with Clause 5.10.2.

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 busbar protection shall be of decentralised, with redundant DC/DC supplies type and 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.

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 Contractor.

Circuit Breaker Failure Protection

Breaker failure protection shall be fitted to all 400 kV circuit breakers of the substation. Separate breaker failure protection on a circuit breaker shall be initiated by all other protection devices which normally initiate tripping of that breaker including the receipt of a direct intertripping signal from a re- mote line end. In the event of the circuit breaker failing to open within a pre-selected time, the breaker failure protection shall initiate tripping of all adjacent circuit breakers. It shall also incorporate provision for initiating tripping of any remote infeeds, via direct intertripping channels over optical fibre commu- nication link or power line carrier circuits.

In the case of circuit breaker failure protection, the position and fault current 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 be capable of remaining in the operated position continuously and of carrying twice the circuit rated current continuously.

The scheme provided shall be suitable for use in a single pole and three pole tripping and auto reclos-ing schemes as appropriate.

The operating time from initiation to back tripping output shall be selected by means of duplicated tim-ers with a setting range of 50-500 msec. The two timers per circuit breaker shall be connected in se-ries in a two-out-two basis and shall energise both trip coils of all adjacent circuit breakers via two back tripping circuits from separate d.c. supplies.
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 tripping.

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 re-lay/scheme shall be designed to accept this input.

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.

Auto-Reclosing Scheme

Three pole and/or single pole, single shot repetitive auto-reclosing equipment, shall be provided for the overhead line circuit breakers.

Reclosure shall be initiated following tripping by either main protection operating in Zone 1 or in con- junction with a teleprotection receive signal. Selection facilities shall also be provided to enable or block three pole delayed auto-reclosing following operation of the directional earth fault protection aid- ed trip output. Reclosure 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 intertripping 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 pro- tection operates nor if the carrier channel is out of service.

The following modes of operation shall be selectable by means of a switch or switches or programma- ble.

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.
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.
Single pole, high speed and/or three phase 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 with- out re-closing shall take place for three phase faults.
No auto reclosing: Three phase tripping without auto-reclose shall take place for any type of fault.

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.

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 pole reclose dead time:	**3 to 30 seconds.**

Bidders shall state available ranges.

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 se- conds. (The reclaim time commences at the instant the reclose command is given to the circuit break- er and, therefore, includes the circuit breaker closing time).

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.

A counter shall be provided to record the number of reclosures and lockout after a pre-selected num-ber of reclosures has been reached.

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.

Reclosing schemes shall include voltage monitoring and check synchronising relays as appropriate.

Dead line check relays shall monitor the condition of the line and busbar and permit three pole reclos-ing 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).

When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall moni-tor 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.

Check synchronising relays shall comply with the requirements of Clause 5.24. 1. The same relays may be used as for manual closing.

5.6 Overcurrent and Earth Fault Protection

The overcurrent and earth fault relays shall be fully Numerical and have multi characteristics (inverse, very inverse, extremely inverse) to IEC 60255.

Overcurrent relays shall have a current setting range from at least 50% - 200% in 25% setting steps.

Earth fault relays shall have a current setting range from at least 20% - 80% in 10% setting steps.

Time multiplier settings shall be continuously adjustable from 0 to 1 or, as an alternative in steps of 0.025 from 0.05 to 1.0.

In the case of transformer circuits relays shall be provided with high set instantaneous units which can be set to 1.25 times the fault current in the HV winding for a fault on the LV terminals computed using the transformer minimum impedance and assuming negligible source impedance. The instantaneous unit shall have a low transient overreach (less than 5% for system X/R ratio of 10) and an operating time of less than 40 msec. at two times the current setting.

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.

Overcurrent and earth fault relays shall trip via the CB duplicate trip coils and initiate duplicated direct intertripping to the remote line end CB.

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 with- stand time of the relay. The Contractor shall provide copies of type test reports to show that this re- quirement has been met.

Directional back up overcurrent and earth fault relays shall be provided for underground Cable feeders and the directional elements shall be voltage polarised.
Directional units for directional overcurrent protection shall be quadrature connected with a relay char-acteristic angle setting of 30° or 45° current leading voltage.

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.

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.

The relay shall be capable of operating correctly when both the operating current and polarising volt-age quantities are 1% of rated values at an angle equal to the relay characteristic angle.

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.

5.7 Transformer Protection

The 420/245/36kV auto transformers shall be provided with dual biased differential protection and re-stricted earth fault relay as a main protection. Redundant biased differential relays shall be provided as shown in the protection block diagram for transformer protection. Directional overcurrent relays and over current relays shall also be installed for back-up protection. Additionally, over flux (V/Hz) relays shall be provided in order to avoid any overheating. For relay and protection connections, refer to the drawing.The detailed protection scheme shall be approved by the Employer.

5.7.1 Biased Differential Protection

The transformer differential protection shall be of 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 latched out-puts. 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 pro-

gramming knowledge. It should be possible to do the settings offline and load the settings on to the re- lay with a standard portable PC with a fibre optic connection.

Overall differential protection shall be of the biased differential type and be capable of detecting phase and earth faults.

Separate facilities shall be provided to enable adjustment of bias and operating settings. The minimum operating setting shall not be higher than 20 % of the rated full load current of the transformer.

The protection shall be designed to ensure stability on any transformer tap position under maximum through fault conditions with maximum d.c. offset. An infinite source is to be assumed, and the through fault current shall be calculated using the transformer impedance only.

Correction for matching transformer vector groups and main CT ratios for transformer differential pro- tection shall be performed within the relay without the use of external interposingtransformer. The relay shall have second harmonic or other inrush proof features. The relays shall have magnetis-ing inrush current restraints of the second harmonic or other approved means. All necessary interpos-ing current transformers shall be provided under the contract.

Where specified in the drawings, two biased transformer differential protection relays shall be provided for each transformer.

The relays shall have an inbuilt event, fault and disturbance recorder. All binary inputs, binary out- putsand analogue channels available in the relay shall be recorded in case of fault.

5.7.2 Restricted or Balanced Earth Fault Protection

Where specified, or shown on drawings, transformer windings and connections shall be protected by restricted earth fault protection. Delta connected windings shall be protected by balanced earth fault protection. Relays shall be of identical numerical design as the main protection and of the high imped- ance type with necessary protection against over voltages. For reliability reasons the restricted earth fault relay shall be separate from the transformer differential relay.

Relays shall have maximum sensitivity and minimum operating times consistent with stability for faults outside the protected zone and on magnetising inrush surges.

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.

For the purpose of calculations it shall be assumed that any neutral earthing impedance is short cir- cuited.

The Contractor shall prepare for approval calculated performance for instantaneous high impedance restricted earth fault protection in lieu of heavy current tests, subject to the conditions in Clause 5.10.2 except:

The rated stability limit shall be as specified above.
The fault setting shall be as specified below.

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 rat- ing.

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.

5.7.3 Transformer Back-up Overcurrent 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 5.12 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.

5.7.4 Gas Pressure (Buchholz) Protection

Power transformers and earthing transformers shall be fitted with Buchholz devices under this con-tract. The Buchholz device will be of the two element type giving operation under gassing and under surge conditions.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be provided, mounted and connected under this contract.

5.7.5 Oil and/or Winding Temperature

Transformers will be provided with oil and/or winding temperature protection under this contract. The-se will be of the two stage type with adjustable settings giving alarm and trip facilities.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be supplied and connected under this contract.

5.7.6 Low Oil Level and Pressure Relief Devices

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.

The alarm relays associated with these devices shall be supplied and connected under this contract.

5.7.7 Tap Changer Oil Surge

Transformers will be provided with an oil surge or pressure operated device having contacts for pur- poses of remote alarm and trip.

A relay associated with this device shall be supplied and connected under this contract.

All necessary flag indication, tripping and alarm relays associated with tap change oil surge shall be provided.

5.7.8 Standby Earth Fault Protection

Standby earth fault protection shall be provided for all earthing transformers/resistors, fed from a cur-rent transformer in the transformer/resistor neutral connection.

The operating current shall be adjustable between 10 and 40 per cent of the resistor value. The time delay shall be adjustable between 1 and 10 secs. As an alternative to a definite time relay, a long in- verse time relay may be offered.

5.7.9 Tripping Relays

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

Trip relay contacts shall be suitably rated to satisfactorily perform their required duty and relay operat-ing time shall not exceed 10 ms. from initiation of trip relay operating coil to contact close.

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.

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

400 kV and 230 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.

5.8 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 suit- able for operation over a voltage range of 66V to 143V. i-e. 110 - 40% + 20%.

5.9 Teleprotection Signalling

Details of protection initiation and various permissive and direct intertripping signals are as specified in Section-14, of Vol. 2 of 3.

5.10 Protection Settings

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.

Any additional information needed by Contractors should be requested.

5.11 Testing

5.11.1 General

All relays (including panels) shall be tested in the Manufacturer's work. The Bidder/Contractor may be required to carry out any or all of the tests stated in this specification

Testing of relays and their components shall be performed in line with this specification and in accord- ance with the relevant IEC standards (as minimum requirement) and other standards as may be ap- proved by PGCB.

Acceptance by PGCB's Representative of any relay tests shall not relieve the Manufacturer from any of his performance guarantees or from any other obligations.

PGCB reserves the right to perform checks during the manufacturing process at any time or all the times

Tests of relays shall comprise factory tests and site tests.

5.12 Factory Tests

5.12.1 Type Tests

Evidence shall be given that the proposed relays to be supplied under the contract had already been subjected to all type tests (including transient and steady-state tests) at an internationally recognised testing station like KEMA or equivalent. If deemed necessary, PGCB will decide whether the Bid- der/Contractor shall perform additional tests.

An internationally recognised laboratory shall certify the type test reports.

The Bidder/Contractor shall submit certified copies of type test certificates covering the proposed relay components.

Type test certificates/reports shall be considered acceptable if they are in compliance with the relevant standards and the following:

Type tests conducted at an internationally recognised laboratory acceptable to PGCB.

Type tests conducted at the Manufacturer's laboratory and witnessed by representatives from an internationally recognised laboratory acceptable to PGCB.

If the presented type test reports are not in accordance with the above requirements, PGCB may de-cide to ask for the type tests to be carried out afresh in the Manufacturer's premises or other places subject to the approval of PGCB and at no additional cost. These tests shall be performed in the pres- ence of an internationally recognised laboratory, which should issue the relevant type test certificates upon successful completion of all tests.

5.12.2 Routine Tests

Protection relays and their components shall be subjected to routine tests as per the relevant IEC standards. Protection relays mounted in cubicles shall be completely wired, tested and inspected at the relay Manufacturer's factory.

Factory tests shall cover a subset of the following:

Secondary injection, scheme checks, relay logic, performance of engineer interface, functional-trip tests, setting ranges and calibration accuracy, response(trip) times, functional availability and ap- plication limits, system supervision, performance of communication interfaces with SAS, events and disturbance records, etc.

The Bidder/Contractor shall provide to PGCB a generic list of tests for approval, depending upon the duration of factory tests, the importance and complexity of the protection system, familiarity of the sys- tem being inspected, etc., However, test procedures shall be prepared to verify adequately the per- formance, functionality and protection reliability.

The Bidder/Contractor shall indicate that the equipment has been manufactured, racked and correctly wired by carrying out approved factory tests.

Routine test certificates shall be submitted to PGCB's review and approval before shipment of the re-lays /panels.

5.13 Site Tests

The site tests of relays shall be mainly based on functional tests, in addition to the visual and wiring checking of the relays, in order to ensure that all components are correctly installed and properly aligned and that there are no imperfections due to damage during transport to site.

Relay site tests shall include comprehensive tests and checks with the protection equipment fully con-nected to the array of all field devices (SAS, FMS, teleprotection signalling equipment, switchgear, CTs/VTs, DC system, etc.).

Checks and tests shall include:

Secondary and primary injections, scheme checks, relay logic, performance of engineer interface, functional-trip tests, setting ranges and calibration accuracy, response (trip) times, functional avail-ability, system supervision, performance of communication interfaces with SAS, events and dis-turbance records etc.

Transient tests shall be included, simulating DC off-sets and harmonics, in order to verify the dynamic behaviour, including the circuit breaker trip time, communication channel time and the effectiveness of the settings adopted.

After energization, load tests shall be carried out.

Prior to field tests on protection relays, the Bidder/Contractor shall provide to PGCB for approval oper-ational settings and parameters to set the protection relays/systems to the substation conditions and power grid requirements.

Calculations for the revision of relay settings (e.g. zone 2 and 3 of distance relays) in the remote end substations shall also be submitted to PGCB for approval.

Setting recommendations shall be submitted for approval at least 2 months before commission-ing /energization.

Separate schedules for on-site tests shall be submitted for approval at least one month before start of the tests.

The results of all tests shall be submitted immediately after satisfactory completion of tests in the form of computer print-outs along with the hand written test sheets signed by PGCB for witness of the tests.

Site test reports shall illustrate all test details as well as details of all applied testing equipment and their calibration validity.

The Bidder/Contractor shall provide a sufficient number of experienced test personnel during inspec-tion tests and at site.

The Bidder/Contractor shall not withdraw or change the test engineer(s) before the completion of all the testing activities, unless it is the requirement of PGCB in the event that the test personnel lacks adequate skills, knowledge or technical expertise for the concerned protection systems /equipment.

Overall tests involving more than one Bidder's/Contractor's equipment shall be suitably and profes- sionally coordinated and arranged by the main Bidder/Contractor. The test and commissioning pro- grams shall be subject to approval by PGCB at site.

The Bidder/Contractor shall carry out any additional site tests, other than those mentioned in the ap- proved site test program, if deemed necessary by PGCB, due to some unforeseen technical require- ments arising from operational contingencies in the network and loading conditions.

5.14 Digital Fault and Disturbance Recorder (DFDR)

The DFDR in PGCB's system are manufactured by Siemens (Germany) 7KE85

The DFDR have the following features:

The equipment shall be an independent stand-alone system to monitor analogue and digital signals from all 400 kV feeders, including transformer and line bays that require to be moni- tored.

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 inter- nationally acclaimed laboratories.

The DFDR system shall be modular in design for easy expansion, upgrade and maintenance.

The acquisition system or its storage unit shall not be based on a PC platform.

The independent DFDR system shall be equipped with a minimum of 40 digital and 8 analogue signals per bay and shall be suitable for AC/DC measurement without any hardware changes.

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 varia-tion, voltage drop, etc., covering all the required feeders.

All input signals shall be able to scan and record simultaneously at least 2 or 3 user-programmable sampling rates from 500Hz to 6kHz for fast (short-term) transient monitoring and from 1Hz to 500Hz for slow phenomena (long-term) monitoring in order to detect and record fast (short-term) and slow phenomena (long-term) events.

At least 25 sec. of memory for transient fault data recording (at 6 kHz sampling rate) and over 1000 sec. for slow (at 30 Hz) phenomena recording shall be provided in addition to the auto-maintained, inbuilt hard disk unit which shall be installed for data storage. The inbuilt hard disk unit shall be managed and operated by the identical industrially proven operating system of the DFDR.

The graphical data should be recorded for all feeders simultaneously (snap shot image).The re-cording should contain the data prior to the event and afterthe event, including the dynamic length of the event / fault without any alterations.

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.

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.).

The DFDR shall be able to communicate with local and / or remote master stations, using mas-ter 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.

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.

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.

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.

The system shall be equipped for time synchronization by the external GPS clock receiver for real time synchronizing (including antenna).

Local printing facility shall be provided with the system.

The master station (a latest version of PC) and the relevant software shall be supplied with the equipment for analysis and communication.

Power quality monitoring or continuous monitoring (periodical recording) shall be made availa-ble for at least 4 feeders.

5.15 Tripping Relays

All tripping relays, where specified, shall be of high-speed (less than 10 ms.), high-burden, heavy-duty (larger than 150W) type and shall be suitable for panel mounting. Relays shall comply with the re-quirements of Clause 5.14.8.

5.16 Substation Automation (SA) System

5.16.1 Scope of Supply

This specification covers the, testing at the Manufacturer's works, and commissioning of a existing substation automation system to control and operate 400/230 kV grid substation.

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.

The substation automation system (SAS) comprise full station and bay protection as well as control, monitoring and communication functions; it shall provide all functions required for the safe and re- liable 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 communication gateway to NLDC, inter- bay bus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing.

The communication gateway 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.

The Contractor 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.

The IEDs for protection and control functions 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 com- munication. No proprietary protocols shall be used.

The system capable of having its computing power increased in the future through the addi- tion of additional computing systems.
The system design life shall be not less than 20 years.

The capacity of the SA system sufficient for the ultimate development of the substation as set out in the project requirements.

The SA Supplier demonstrate that the proposed system has been designed, installed and com- missioned in accordance with the IEC 61850 standard and shall provide evidence of satisfactory ser- vice experience during the past 5 years.

For detailed technical data, please refer to the technical data schedules.

These specifications describe the functional requirements of the substation control and supervisory system. The frame structure of these systems is also defined. For implementation of these require- ments, the Contractor shall use standard hardware and software to the maximum possibleextent.

The optimum solution of the substation control and monitoring system for the considered substation is realized by three functionally independent subsystems:

the substation control system
the protection system and protection supervision
system the switchyard interlocking system

The protection system is described in a separate section of these specifications.

Both substation control and interlocking system should a have hierarchical structure, which best suits the substation design, functions and its importance for the power system. The Contractor has to pro-pose such a particular, his own, optimal solution and confirm its advantages and give the related ref-erences confirmed by the Employer. The Contractor shall confirm continuity of his preferable philoso-phy of the proposed solutions, utilization and compatibility of new products in the next 15 years after commissioning.
The system between the bay control level and the substation control level and linked with higher level control centre shall be of the "open" system design, i.e.:

it must be possible that equipment from different manufacturers works together, easy extension shall be possible,
future upgrades (hardware and software) must be easily possible without changing existing equip- ment or interfaces. Implemented protocols should also be replaceable without major modifications (e.g. future IEC standards).

For the purpose of the cooperation of equipment from different manufacturers, the internationally recognized and approved standard communication protocol shall be applied. The substation control and supervision system shall have minimum 2 (two) interfaces for communication with the control centre.

5.16.2 Compliance with Standards

For design and type-testing of the protection and control equipment, the following standards shall ap-ply:

5.16.2.1 Standards for Environment

IEC 60068-2-1/2: Environmental testing: Temperature
IEC 60068-2-3: Environmental testing: Humidity
IEC 60654: operating conditions: climatic conditions
IEC 60870-2-2: telecontrol equipment and system: environment conditions

5.16.2.2 Standards for Equipment

IEC 60044-1: current transformer
IEC 60056: earthing switch
IEC 60185: low voltage switchgear
IEC 60186: voltage transformer
IEC 60688: electrical measuring transducers
IEC 60227: polyvinyl insulated cables
IEC 60228: conductors of insulated cables
IEC 60297: dimensions of mechanical structures (19" panel, racks, cabinets etc.)
IEC 60309: plugs, socket-outlets and couplers
IEC 60352: solderless connections
IEC 60529: degrees of protection provided by enclosures
IEC 62271-100: high voltage alternating circuit breaker
IEC 62271-102: Alternating current disconnectors and earthing switches
IEC 60129: high voltage switchgear and control gear. Alternating current disconnectors and earth-ing switches.
IEC 60146: Rectifiers, converters, stabilized power supply.

5.16.2.3 Standards for Tests, Safety, Definitions

IEC 60605-7: Equipment reliability testing
IEC 60271: tests
IEC 60073: Basic and safety principles for man-machine interface
IEC 60050: international electrotechnical vocabulary
IEC 60038: IEC standard voltages

5.16.2.4 Standards for EMC

IEC 61000-4-2: Electromagnetic compatibility - electrostatic discharges
IEC 61000-4-3: Electromagnetic compatibility - electromagnetic field

IEC 61000-4-4: Electromagnetic compatibility - fast transient (burst)
IEC 61000-4-5: Electromagnetic compatibility - impulse voltage immunity requirements (lightning)
IEC 61000-4-6: Electromagnetic compatibility - continuous wave (CW) current injection.
IEC60801: Electromagnetic compatibility for electrical and electronic equipment
IEC 60255-6: electrical relays: HF interference test.
IEC 60255-22: electrical relays: electrical disturbance tests
IEC 60255-3: electrical relays: surge voltage test
IEC 60255-5: electrical relays: HF interference test
IEC 60870-2-1: telecontrol equipment and system: power supply and electromagnetic compatibility

5.16.2.5 Standards for Interfaces

IEC 61850 Edition 2: communication networks and systems in substations.
IEC 60870-5-101: telecontrol equipment and system: transmission protocol (telecontrol tasks)
IEC 60870-5-102: telecontrol equipment and system: transmission protocol (integrated total in elec-tric power systems)
IEC 60870-5-103: telecontrol equipment and system: transmission protocol (informative interface for protection equipment)
IEC 60870-5-104: telecontrol equipment and system: transmission protocol: network access
IEC 60870-3: telecontrol equipment and system: Interfaces (electrical characteristics)
IEEE 803: Ethernet LAN

5.16.2.6 International Standards Organisation

The Manufacturer of the substation control and supervision system shall submit a certificate of a quali-ty assurance system according to ISO 9001 in design, development, production, installation and ser- vicing.

ISO 9001: Quality system model for quality assurance in design/development manufacture and testing.
ISO 9002: Quality system model for quality assurance in production, installation and servicing.

5.16.3 General System Design

The SAS contain the following main functional parts:

- **Human Machine Interface (HMI) with process database**
- **Gateway function for remote control via an industrial grade hardware**
- **Dial-in facility / laptop workstation for protection relay parameterisation, disturbance analysis and SAS fault analysis.**
- **Data exchange between the different system components via high speed bus**
- **Bay level devices for control, monitoring and protection**
- **Bay-oriented local control and protection panels with mimic inserts**
- **Facility for emergency operation of all the switchgear, if the bay controller fails (key / master key system).**

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 availabil-

ity reasons. Functions shall be decentralised, object-oriented and located as close as possible to the process.

The substation monitoring/protection system shall supply data for maintenance, repair and remote pa-rameter setting of protection and control devices in the switchyard

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.

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.

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 minimise maintenance.

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.

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 parameterisation) shall be pro- vided with associated tools and equipment. The required engineering tools and analysing software shall also be provided/installed both in the station PC and the remote master analysis station. A back- up copy of all the software shall be provided on CDs.

The SAS 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 mi-crowave channel.

5.16.4 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 de- vices that can be freely adapted to the requiredapplication functions.

5.16.5 System Hardware

Bay Control Level
For detailed technical data, please refer to the Technical Data Schedules.

Distributed (bay orientated) microprocessor devices, hierarchically linked with the central substation control unit, are foreseen for bay control. The physical location of this device is inside the relay panels (with protection devices) together with the local backup panel for emergency control.
A specially designed controller (local RTU) must be foreseen for acquisition of data gathered on the substation level (aux. supply AC/DC, fire alarm, burglar alarm, etc.).

The bay level equipment shall comprise at least the following elements:

Bay computer,

Input/output equipment for digital and analogue signals. The exact number of needed I/O must be given from the Contractor's side after careful evaluation of the final design and chosen equipment. 20% of spares must be foreseen,

Communications with protection equipment and interlocking unit,

Local mimic for backup or maintenance control and monitoring of equipment in the bay.

Data Acquisition and Input

The digital alarms input shall allow collecting of signals e.g. alarm, fault and status signals from HV apparatus and other indications from the power process. The input ports shall accept single and dou-ble status inputs with the usual signalling voltage of 110 V DC without any additional interposing relay or signal transformation. The digital inputs must be routed into the control system via galvanic sepa-rated interference barriers or in a special case from a serial process bus. In this last case, all optical elements and communication microprocessors shall be delivered.

All incoming digital signals shall be stamped with a time tag. The mode of time tag shall be selectable. Each binary input shall be subject to application of filters to detect oscillation of contacts or malfunc-tioning of inputs. The filter shall be configured in such a way that each change of digital input shall last at least 10 to 100 ms., adjustable before selection, yet maintain event's real-time reporting of up to 1 ms. accuracy. The required signal levels for the input units are as follows:

Digital input signals 110 V DC.

Analogue current signals 1 A AC.

Analogue voltage signals 100 V/√3 and 100V/3 AC.

All switches are with insignificant status, and all push buttons are one-bit status. Metering (bay controller display):

all currents,

all voltages,

active and reactive power (both directions).

The scaling of analogue signals shall allow for a dynamic range of 5.0 p.u. for current signals and 2.0 p.u. for voltage signals.

Indication

A separate block of the bay level control system shall provide backup control system - backup panel (used in case of the break of communication with the substation processor or in case of maintenance work in the switchgear). If the substation control system is switched off or defective, the scheme shall provide the possibility of controlling at the bay level by authorized personnel with button commands. This shall be still possible even if the power supply module within a feeder unit fails.

The backup system shall include a mimic diagram (mosaic) providing the following functions:

Metering: All voltages (V-switch), one current (phase "4"),

HV switching equipment position status (circuit breakers, disconnectors, earthing switches), Command of the circuit breaker and disconnectors,

Pole discordance signal for all switch gear devices, Motor drivers not ready signal,

Pressure low signal,

MCB trip signal,

Aux DC out signal,

Switch on/off local control,

Breaker trip circuit supervision signal, Protection failure signal,

Protection trip issued - breaker tripped signal.

All switching operations performed by the backup system shall be recorded in the bay level computer (switches states - 2 bits, push buttons - 1 bit).

The following display and control devices shall be mounted on the front panel of the I/O units:
An analogue display showing values of phase and line voltages (switched), and central current (phase "4"),
Control command indicators,
Indication of alarms with memory for transient signal(s), Backup control switch,
A push button for the signal indications resetting,
A push button for signalisation lights testing (Annunciators), Supply switch.

Control

Control outputs of the bay level computer shall enable direct control of the operational elements (switch coils, tap changer, etc.).

One two-position switch shall be provided on the control panel performing the following functions:
LOCAL - only local control is enabled; the interlocking function is on bay level only, no synchroniza- tion, REMOTE - only remote control is enabled.

In both cases, all data are transmitted to the higher level (control centre).

The BCU shall allow operation of the switchgear (e.g. circuit breakers, disconnectors) and other equipment (e.g. tap changers) located in the bay according to: commands received from the substa- tion control system, the portable PC terminal or the local mimic backup control panel.

It shall be possible to disable control of each switching element separately, both locally and remotely.

Output

The digital output command unit shall offer a minimum of interface relays for direct operation of circuit breakers and other switchgear apparatus as well as for signalling outputs. The output relay for opera-tion of switchgear devices shall be of the heavy-duty type for up to 220 V DC, with the current rating of 10 A at 110 V DC + 20%. The signal output relays shall be designed for a voltage rating of up to 220 V DC and a continuous current of 1 A DC.

The required signal levels for the input and output units are as follows:

Digital output signals 110 V DC.
Command for disconnectors and for circuit breakers.
All commands are given in two-step sequences.

Fault Analysis Function

An event recorder Sequence of Event (SoE), fault location and fault recorder function (disturbance re-corder) shall be provided at the bay level. This function shall be provided through independent meas-urement of the signals by the bay level computer or in conjunction with the digital relay system. SOE is mandatory in bay computer and relay protection. For fault recorder and fault location function logging, linking between digital relay system (serial interface ports between the bay level digital relays) and substation control system shall be provided. The unit shall be capable of storing past events in a data- base; no data shall be lost on interruption of the auxiliary supply.

Communication

A communication port for operation and maintenance through portable computers shall be provided for maintenance and emergency control purposes. Each bay level computer shall have a port for connec- tion the portable PC, to be used for:
bay operations,
stored data reading,
the recorded analogue signals analysis (if needed), maintenance.

The switching operations performed by the backup system shall be recorded in the bay level comput-er. The switching operations with or without interlocks should be done by authorized personnel only. Provisions for password protection or physical key interlock shall be made.

Synchrocheck Function

The synchro-check functions of the protection relays shall be used to ensure safe and reliable closing and reclosing operations. Circuit breaker operation shall be possible when synchronization conditions between two systems to be connected are fulfilled (voltage difference, phase angle difference, fre- quency difference). The busbar voltage shall be the reference voltage.

Synchronization criteria (U, f) shall be displayed on operator VDU. Means for remote synchronization check shall be possible.

Interlocking System

This requirement involves perfect collection and processing of all switchyard positions of the whole substation at all times. Unclear information, such as intermediate switchgear positions, switchgear fault, faulty data transfer must never allow switching operations.

Because faults can have serious effects on the operating personnel, the function and design of switchgear interlocking systems must be extremely safe.

The switchgear interlocking system should provide both bay interlocking and substation interlocking facilities.

This system should operate properly in the event of control system outage. The interlocking system on bay level will be managed through conventional (wire) interlocking and should be enabled in case of an emergency command from a backup panel. Same elements of the interlocking system (wire bay in- terlocking) should be used for the bay controller from command and interlocking (from a bay level). For substation interlocking (inter bay interlocking), only software interlocking should be used. For medium voltage switchgears (aux. supply), only combined protection and control units should be used. The Contractor can choose an optimal communication medium for them, and software only interlocking.

For circuit breaker command from backup panel, no synchronization check is foreseen. Global inter- locking shall provide the following functions:

- **Interlocking at the bay level and on the inter-bay or station level in conjunction with the station con-trol system. While inter-bay interlocking will normally be performed at the switchyard control level, it shall be possible to manually override the inter-bay interlocking at the bay level if the substation control system is not functioning,**
- **The central unit of the switchyard interlocking system (if needed) shall communicate with corre- sponding feeders through its own serial data lines, which are independent from the other compo- nents of the control system,**
- **Simple extension shall be possible without changing of the hardware on switchgear level,**
- **Serial data transmission to the interlocking system shall be continuously monitored,**
- **Self-monitoring of the switchgear interlocking units, the station connection and the parameterised interlocking conditions shall be provided,**

Modification of the interlocking system shall be easily possible by changes in the software.

Interlocking Functions

The subsystem shall meet the requirements and fulfil the functions as follows:

- **The interlocking functions on the bay and switchgear level in connection with substation control system. Whereas under normal conditions the interlocking functions will be provided on the substa- tion level, provisions shall be made to overcome interlocking on the bay level if the substation con- trol system is locked.**
- **Self-monitoring of the switchgear interlocking functions / units, the station connection and the pa-rameterised interlocking conditions shall be provided.**

If a central unit will be provided for the higher-level station interlocks as an independent element, it could be integrated in the bus tie. The central units of each switchgear Interlocking system shall communicate with the corresponding feeders through its own serial data transmission network, which shall be independent from the other components of the control and protection system.

A solution with an interlocking system independent from the substation control system (e.g. central substation computer control system) is preferable.

If defects in the feeder units appear, the rest of the system shall remain operational in terms of sta- tion interlocks as well as the last switchgear status. This assumes that the identified defective bay unit will not carry out incorrect switching operations. However, in case of emergencies, authorized personnel can operate the defective unit located on the back-up panel with a push button. This shall be still possible even if the power supply module within feeder unit has failed.

Extension of the system shall be easily possible without hardware changes on the substation level.

5.16.5.1.2 Bay Control Units (BCU)

General

The central substation control unit is a microprocessor(s) based device (hardware and software) with an adequate performance level to satisfy requests for substation control remote communication with the National Load Despatch Centre, local by controllers, protection devices and with sub-RTU units.

There are two HMI (workstation, the second workstation can be used as an Engineer workstation) with two VDUs, two substation servers working in hot stand-by redundant mode, two gateways, printer, work place for maintenance and GPS.

The substation control system must support various protocols also for the existing part (in upper or lower direction), which are by the rule from the IEC family (61850, 60870-5-101, 60870-5-104 60870-5-102 and 60870-5-103). Furthermore, it must support future expansions of the substation control sys- tem (meaning end stage of substation project), having a 25% reserve of resources as minimum. Communication inside the substation should preferably be done through fibre optic cables. Communication toward LDC is performed via the existing gateway of Aminbazar 230/132/33 kV substation.

The substation level equipment shall comprise the following elements:

HMI (main and backup) including two video display units for one HMI, keyboards, mouse and print- ers, one HMI being used for operation (It is the main one). An engineer workstation is available. In case of failure of the main HMI, the engineer workstation can be used as HMI for operation.

Two hardware station computers working in hot stand-by mode,

Communication devices to enable data exchange with NLDC via the gateway of Aminbazar 230/132/33 kV

Workplace for engineering and maintenance when laptop for maintenance will be connected.

GPS receiver that should run on SNTP protocols. The satellite clock will provide the reference time to the comprehensive Substation Control and Monitoring System and protection relays through IEC61850 substation LAN

It shall be possible to transmit single or all data to the substation level on request in the moment they occur.

It shall be possible to access the stored data and to analyse and evaluate them on each hierarchical level (starting from bay level up to control centre). The access and analysis of the data from the local port shall not disturb the normal performance of other control functions on the substation level.

The control substation computer shall also collect and process commands both from the control and display unit and from the control centre and shall distribute these commands to the individual I/O units of the bay computers.

The substation computer shall be capable to address to all terminals (at the bay and substation level) according to actual and final stage substation configuration; additional 20% spare should be foreseen.

5.16.5.1.3 The substation computer should be capable of maintaining a record of current and previous HMI con- figurations and should allow easy configuration changes by means of a GUI-based system.

Substation Control Level Functions

The substation control level equipment shall provide the following functions:

Duplex communication with NLDC,
Communication with substation protection system (including disturbance recordings), Status indication,
Remote and local control of switchgear devices (circuit breakers, disconnectors, earth switches), Alarm annunciation/processing/recording,
Measurement,
Data acquisition/logging/processing/distribution, trends of analogue values, customized reporting, Fault recording,
Registration/tagging,
Sequential switching commands bay and switchgear oriented, Sequence of events recording (SOE),
Remote parameterizing,
Transformer control,
Communication with interlocking system,
Cooperation with automatic voltage control, Disturbance (oscillate) viewing,
Fault location viewing (%, km),
Clock control (GPS time distribution), Self-monitoring,
Communication with HMI.

The substation control system should have a structure according to a "button-up" logic. This means that data from lower levels (e.g. bay level) are not transmitted 1:1 to the higher level (e.g. substation

level), but as a pre-processed package. Especially in case of greater faults, the higher-level network control centre can be relieved by this method, because the data concentration in the switchgears dur- ing stress situations avoids the so-called "Christmas tree" effect in the NLDC. Choice of authority for controlling should be done by software, according to hierarchy, without the possibility of emitting commands from two different places at the same time.

The substation control system shall provide all control and signalling facilities required in the substa-tion such that the status of the substation can be ascertained and all the necessary control and switch-ing operations can be carried out from the central control room.

The above-mentioned functions shall be provided either locally in the substation and/or from the con-trol centre. Operator communication and interfacing with the control system shall be via an interactive menu, keyboard (functional or conventional) and mouse.

To limit the number of cables and ensure extension of the system, the exchange of the information be-tween distributed single bay units and the central substation system shall be performed through re- dundant fibre optic wire.

Data acquisition and processing shall take place in real time with a resolution of 10 ms. for switching operations and 1 ms. for fault data generated by the digital protection equipment. Analogue value measurement shall be carried out every 1 second.

Every action shall be confirmed by return signals generated in chronological order, they shall be pro- cessed and displayed on a screen (VDU) and simplified mimic board on the backup control panel (with LED indicators displaying only status of switching equipment) and shall be transferred to the control centre.

A facility to print out events and alarms shall also be provided.

In the event of loss of supply, the system shall restore and update the status of all devices automati-cally when the supply recovers. The updating process shall not inhibit the rest of the system functions.

5.16.5.1.4 Voltage Regulation

Control of the transformer tap changer (rise and lower) from the substation computer keyboard shall be provided with simultaneous indication on screen. The tap changers (OLTC) control and indication from the control centre shall also be provided.

Each transformer (with OLTC) shall be equipped with its own voltage regulator or shall be controlled by complex joint voltage regulation system provided by third party. Selection of automatic or manual initiated tap changer control shall be provided. Parallel regulation is not foreseen, and such operation must produce a warning but shall be an allowed operation.

5.16.5.1.5 Protection Monitoring System

The Contractor shall propose the protection monitoring system which is (as a function) independent from the station control system for the remote relay monitoring and fault analysis. It shall have the possibility to be used for station diagnostics. This system shall allow for:

Monitoring and diagnostic of protective equipment,
Access to the relays and overview of relay setting from a local and remote location, Protection performance analysis,
Fault recording and fault location determination,
Analogue fault data acquisition and storage,
Transmission of fault data to remote location for analysis, Reports,
Communication with control system connection of the HMI for diagnostic functions of the primary equipment,
Remote parameter reading/setting for protection devices is welcomed.

At the substation level, an expert system / advanced help utility should be provided with facilities for transmission data to the control centre.

5.16.5.1.6 Data Security

Substation control and supervision system shall provide the security and diagnostic functions of the individual system elements especially for:

Monitoring and diagnostic of auxiliary equipment:
- **Auxiliary supply,**
- **Auxiliary air conditioning systems,**
- **UPS systems.**

Monitoring and diagnostics of the air conditioning system,
Monitoring and diagnostics of the firefighting system,
Monitoring and diagnostics of the alarm system, Access to the files,
Transmission and execution of commands, Serial data communication,
Data storage,
Coordination of functions,
Conformity of the substation equipment with the single line diagram.

To achieve high reliability of the system operation, actual faults shall be time tagged in the moment they occur but not in the cycle time of the process. Software data and parameters shall be stored in solid-state memory, which does no lose its contents in a case of loss of supply. The software and da- tabase shall automatically restore after recovery of voltage.

5.16.5.2 System Design

5.16.5.2.1 Hardware

The system hardware designed as interchangeable elements of the standard formats or as compact modules (according to IEC 60297). It shall have an "open" structure and design so that ex- tension of the system should be easy. The hardware shall meet the following specifications.

5.17 Busbar Voltage Selection

Where required, selected voltage references, one for each busbar, shall be employed for all indications, metering, protection and synchronizing 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 di-rect use of auxiliary contacts on busbar selector switches.

5.18 Energy Meter (Tariff Metering)

5.18.1 Normal Display List

Scroll Order	Display Item Name
1	Complete LCD test
2	Present date
3	Present time
4	Current billing total kWh-Del
5	Current billing total kWh-Rec
6	Current billing total kVARh-(Q1+Q4)
7	Current billing total kVARh-(Q2+Q3)
8	Current billing maximum kW-Del
9	Current billing maximum kW-Del Date
10	Current billing maximum kW-Del Time
11	Current billing cumulative kW-Del
12	Current billing maximum-Rec
13	Current billing maximum kW-Rec Date

Scroll Order	Display Item Name
14	Current billing maximum kW-Rec Time
15	Current billing cumulative kW-Rec
16	Phase A Voltage
17	Phase B Voltage
18	Phase C Voltage
19	Phase A Current
20	Phase B Current
21	Phase C Current
22	Phase A voltage angle
23	Phase B voltage angle
24	Phase C voltage angle
25	Phase A current angle
26	Phase B current angle
27	Phase C current angle
28	System PF-arithmetic
29	Line frequency

5.18.2 Alternate Mode Display List

Scroll Order	Display Item Name
1	Complete LCD test
2	Present date
3	Present time
4	Current billing total kWh-Del
5	Current billing total kWh-Rec
6	Current billing total kVARh-(Q1+Q4)
7	Current billing total kVARh-(Q2+Q3)
8	System PF-arithmetic
9	Line frequency

Load profile (cumulative meter reading) and Instrumentation profile data in the following format should be stored in intervals of 30 min for at least 100 days:

5.18.3 Interval Date (Load Profile)

Interval Data Mode: Cumulative Engineering Units

Time	kWh-Del	kWh-Rec	KVARh-(Q1+Q4)	kVARh-(Q2+Q3)
Date: 1/31/2015				
00:00	0	0	0	0
00:30	0	0	0	0
01:00	0	0	0	0
01:30	0	0	0	0

5.18.4 Interval Date (Instrumentation)

Set-1

Time	End Phase A Voltage	End Phase A Voltage	End Phase A Voltage	Average System kW
Date: 1/31/2015				
13:45	61.0544	61.1424	61.072	0

Set-2

Time	End Phase A Current	End Phase A Current	End Phase A Current	Average System PF-Arithmetic
Date: 1/31/2015				
13:45	0.0008	0.0004	0.0004	-0.7002

Self-read feature for at least 12 months' billing history.

Auxiliary Power and Control Cables

6.1 Scope

A complete cabling system for the substation auxiliary power requirements and the control and protection multicore cabling shall be designed, provided, installed and commissioned by the Contractor as specified in the Project Requirements and schedules. All ducts, cable racking and supports are to be supplied under the Contract. The Contractor 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 Contractor, who shall be responsible for design, procurement, installation and works/site testing of the whole installation.

The Contractor 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 Engineer.

The Contractor shall provide an installation in accordance with the best modem 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 Contractor shall submit to the Engineer drawings for approval showing the proposed cable routes, cross-sections of the trenches and arrangements of the cable racks and trays.

The Contractor shall prepare and provide all necessary cable schedules. The cable numbering system to be used shall be advised to the Contractor and this system shall be followed.

The Contractor 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 IEC standards and recommendations, or any other Internationally recognised standards, subject to the approval and acceptance of the Engineer.

6.4 Cable Installation

6.4.1 General

The cabling system shall be designed to incorporate maximum practical security, to ensure that an in- cident such as fire causing loss of cable circuits in any one route would at worst result in the interrup- tion in operation of one unit only. Cables with reduced fire propagation characteristics shall be provid- ed.

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:

directly buried
in concrete trenches (on racks or trays)
in ducts
in air

Control and instrumentation cables shall be screened/shielded to minimise interference, where neces- sary.

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:

Group A: Single core power cables,
Group B: Multicore power cables,
Group C: Multicore control cables and protection cables,
Group D: Multi-pair 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 multi-pair (Group D) instrumentation ca- bles 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 re- duced where the two types of cable only run in parallel for a limited distance, provided the Contractor 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 Electro technical Commission or equivalent, and details for the cable designs offered shall be given in Schedule E of Particulars and Guarantees.

The Contractor 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 Contractor 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 Engineer.

6.4.5 Cable Sizing and Routing

The Contractor 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 limita-tions**
- **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 de-rating 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 fac- tors.

All power cables shall be adequately rated to withstand the thermal and magnetic effects of short-circuit 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 short-time rating of all transformer and interconnector feeders shall correspond to the maximum short-circuit conditions and be based on the previous maximum continuous rating operating tempera- ture, 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 back-up protection to operate and isolate the circuit. When protected by a circuit breaker which is not of the current limiting type, the ca- ble shall withstand the maximum fault current, including asymmetric peak, for at least 3 seconds with- out damage.

For 400V motor supply cables the rating shall be based upon the duration of the let-through 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 short-circuit 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 Contractor 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 Contractor shall ensure that satisfactory operation will be achieved under overload or short circuit conditions on the system.

The Contractor shall furnish copies of calculations and other details to show how the ratings and cross-section areas of all cables have been obtained and the de-rating factors for which allowance has been made. Where a cable is routed through differing types of installation conditions, the condition giv- ing the lowest cable rating shall determine the cable size.

The sizes of all cables shall be submitted to the Engineer for approval and the Engineer may require the Contractor to increase the cross-sectional area of the conductor to ensure that the required current carrying capacity and performance is obtained. All such changes shall be made by the Contractor 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 re- tardant characteristics of BS 4066 and IEC 60332.

PVC sheathing shall comply with IEC 60540 and shall have flame retardant properties such that the Oxygen Index is not less than 30 when tested in accordance with A.S.T.M. D2863-77. 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. Single-core 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, non-hygroscopic 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 non-returnable and shall be made of timber, pressure impregnated against fun-gal 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 Engineer'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, sol- dering metal, glands, filling and drain plugs, armour clamps, earth bonding terminals and filling com- pounds as appropriate.

Mechanical glands for the termination of elastomeric or thermoplastic insulated cables into straight- through joints and termination accessories shall meet the requirements of BS 6121 and shall be cor- rectly 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 with-stands 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 de- pended 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 inter-posed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

Outdoor 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 15˚C and 65˚C 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/ 1 kV. They cables shall have stranded copper conductors.Insulation shall be XLPE with an operating temperature of 90˚C.

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 min 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 (110V d.c. maximum) used on instrument and Logic Transmis-sion Systems. These cables shall be multiple twisted pairs, screened and PVC covered with conduc-tors sized 1.5mm²minimum. 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 com-binations 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 ca- bles.

6.6.2.2 Multicore Control Cables

Cables shall comply with the construction here above and shall have cross-linked 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 a voltage rating of 0.6/1 kV, except that 2.5 mm² copper conductors shall be stranded (7/0.67mm wires). Standard de-signs shall be for cables with 2, 3, 4, 8, 12, 16, 24 and 36 cores, and single strand conductors will be accepted at 1.5 mm².

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 cur-rent and voltage transformers and for circuit breaker and contactor control circuits.

6.6.2.3 Multi-Pair Instrumentation Cables

Multi-pair instrumentation cables shall be provided in accordance with industry standards.These ca-bles 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 ar- mouring.

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 cur-rent rating not exceeding 20 mA, where considerations of interference and cross-talk are of great im-portance. Typical applications include communications, computer signals, transducer circuits and alarms.

6.6.2.4 Oversheaths

All the cable types above shall have a black flame-retardant low smoke PVC oversheath. In normally manned locations, especially the control building, cables shall have a low smoke, zero halogen over-sheath, so as to minimise the generation of smoke and corrosive acid gases in the event of a fire.

6.7 Straight-through Joints

Each cable shall be run in one continuous length. Straight-through 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 Engineer. Cables shall be installed by the following methods only:

in concrete
trenches in ducts
on cable racks or trays.

Concrete trenches shall be provided in switchrooms. Cables shall be installed in a manner which per-mits 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 Engineer's approval shall be installed at all, points where the cable is vul-nerable 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. In outdoor locations ca- bles shall be provided with mechanical protection from ground level to a minimum height of 1 metre or the cable box on the apparatus, whichever is lower.

Cables shall be installed in such a manner as to avoid undue risk of damage during installation. The Contractor 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 Engineer.

Sunshields shall be provided in all locations where the cable would otherwise be subjected to direct sunlight.

6.9 Cables laid directly in the Ground

The method of installation shall be as follows:

Trenches shall be excavated to the minimum depth shown in Drawing for cable trench. Covers shall be provided over cables laid in the trench.

Filling in of trenches shall not be commenced before inspection and approval by the Engineer of the cables and accessories in-situ.

The Contractor shall lay the cables direct in the ground in the following manner:

70mm minimum of builders fine and graded and washed sand or other approved material shall be placed to form a bed for the cables.

After the cables have been laid they shall be covered with additional riddled sand well punned over and around the cables. No mechanical punners shall be used for this work. Protective covers of con- crete shall be provided and installed.

Where, in the opinion of the Engineer, the soil on the site is unsuitable for backfilling, the Contractor shall arrange for the importation of suitable material.

Where three single core cables are laid direct in the ground and form one three phase circuit, they shall unless otherwise stated, be laid touching one another in trefoil formation, with one cable upper- most. In order to maintain a trefoil formation the three cables shall be tied together with tarred twine or by other approved means at intervals of 1.5m.

Unless otherwise approved, auxiliary control cables shall be laid under the same covers as the power cables and there shall be at least 50mm of riddled sand between the two types of cable.Above the protective covers (tiles) there shall be provided 150mm wide Teri-tape in yellow with "CAUTION - ELECTRIC CABLE" in English.

After any cable has been laid and until all of the cables to be laid in the trench have been covered with their protective covers, no sharp metal tools, such as spades or fencing stakes, shall be used in the trench or placed in such a position that they may fall into the trench. Rollers used during the laying of cables shall have no sharp projecting parts liable to damage the cables.

6.10 Cables drawn into Ducts

Ducts and pipes 35mm minimum in excess of cable diameter shall be supplied and installed by the Contractor in accordance with the building and civil works section.

Ducts shall be of rigid PVC and shall be surrounded by concrete of minimum thickness of 150.

Before pulling cables through ducts, the Contractor 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 Con- tractor before backfilling.

The ducts shall be water and vermin proof sealed, after completion of cable installation.

6.11 Cables installed in Concrete Trenches

The cable trench system shall be designed by the Contractor to the approval of the Engineer. 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 Engineer.

The Contractor shall be responsible for removing and replacing the trench covers free of charge dur-ing the execution of his work as directed by the Engineer.

6.12 Cables Supported on Racks, Trays, etc.

6.12.1 General

All single core and multicore main power cables shall be installed in cleats or saddles fixed at inter-vals. Multicore power cables shall be installed on trays or racks 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 ex- cessive sagging. The Contractor shall include for the preparation and provision of single line cable routing drawings and detailed cable supporting steelwork drawings, necessary to enable the Engineer 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 ar- ranged 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 earth- ing/grounding system. Bonding and grounding connections shall be adequate to carry prospective fault currents without exceeding thermal or voltage limits.

6.12.2 Supporting Steelwork

All supporting steelwork shall be hot dip galvanised after manufacture and shall be to the approval of the Engineer.

Steelwork section shall not be less than 50 x 50 x 6 mm for steel channels and 50 x 50 x 5 mm for an- gles.

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 1 m un- less otherwise approved by the Engineer.

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 Contractor shall, if required, demonstrate that the loading resulting from the attachment of cabling steelwork has been taken into account in the steelwork design.

6.12.3 Cable Clamps, Cleats, Saddles and Ties

For single core cables carrying three phase alternating current, non-magnetic 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 non-flexible type cable shall be securely supported at a point not more than 1 m from its termi-nal gland to prevent stressing the termination, and on vertical runs passing through floors, immediately above the floor.

6.12.4 Trays and Racks

The Contractor shall provide all necessary trays or racks which shall be fixed at not more than 1 m centres. On all main runs trays or racks shall be installed to accommodate additional cables to the ex- tent of 50% of those installed under the Contract or known future requirements.

Cables shall be installed on trays, in general as follows:

Up to 16 mm² - double layer touching.
25 to 70 mm² - single layer touching.
Above 70 mm² - single layer with 25mm (minimum) spacing.

All cable trays shall be perforated.

All trays and racks 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 or racks shall not proceed until the Engineer's ap-proval for such has been obtained.

Where cables are run on trays or racks, they shall be tied to the tray at 1 m intervals using materials approved by the Engineer.

The cable tray system shall have minimum of 20% spare cable capacity throughout.

6.13 Cables Installed on Structural Steelwork and Brickwork or Concrete

The majority of cables shall be routed on steel racks or trays but where cables have to be installed on buildings and building framework the cables shall be held by spacer saddles or cleats screwed or welded in position. The Contractor shall supply all necessary spacer saddles or cleats and fix these in position in the least obtrusive manner possible, copper cleats being used for copper sheathed MICS cable.

Cables shall not be routed on tiled, lagged or other special finished surfaces.

6.14 Terminations

6.14.1 General

The Contractor shall be responsible for making all terminations, checking and setting-to-work 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 ter- mination 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 Engineer.PVC, XLPE, silicone rubber and PTFE insulated cables shall be terminated via glands to BS 6121.

Glands in all outdoor locations and within the Substation and other areas where water may impinge on cables shall be type EIU, with inner and outer seals and armour clamp. Unarmoured single core ca-bles 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.

6.14.2 Power Cables

The Contractor 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 Engineer and, if found necessary, the Contractor shall carry out the re- versal 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 Contractor shall ensure that the insulation is maintained af-ter jointing the cable and shall, if required, demonstrate this to the satisfaction of the Engineer. The tails of two or three or four core cables in air insulated terminations shall be identified by a band of ap- proved tape of appropriate colour over the self-sealing tape.

Single core cables shall be similarly identified by coloured tape over the cable beneath the gland.

6.15 Terminating and Jointing Conductors

Compression (indentation) type cable lugs and ferrules shall be provided and all necessary tools, in- cluding dies and other materials for making compression joints, shall be provided by the Contractor, 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 excep-tion of flexible conductors having wires of 0.3mm or smaller which shall be fitted with crimps to more than one conductor shall be terminated in each clamp.

6.16 Core Identification

A uniform core identification system shall be used throughout the Station. The following clauses out-line the broad requirements but the exact implementation shall be agreed with the Engineer.

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 fer- rules 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) fol-lowed 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 corre- sponding 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.

6.17 Cable Identification and Schedules

The Contractor shall prepare and submit computerised cable schedules, the content and style of which shall be to the general approval of the Engineer. These shall include cable identification num- bers 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 Engineer.

The Contractor 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:

- **By cable identification number only**
- **By type and size of cables**
- **By function of cable**
- **By main LV AC and DC,switchboard, actuator boards.**
- **By agreed electrical and mechanical plant functional groups.**

The Contractor shall provide copies of the cable schedule in an approved format. The Contractor shall provide a standard software package together with a suitable personal computer to permit the Engi-neer to access, display, print and edit the schedules. The schedules shall be accessed by simple in-teractive dialogue using 'menu-selection' or other approved procedure.

In addition, the Contractor shall provide selected copies of the above schedules in a computer print- out format agreed intervals.

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 refer- ence 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.

Earthing System and Lightning Protection

7.1 Scope

These chapters 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/std 80 IEEE Guide for Safety in AC Substation Grounding
ANSI/IEEE/std 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grounding System

7.2.2 German Standards

VDE 0140	**Earthing Systems for Power Installations with Rated Voltages above 1 kV**

7.2.3 British Standards

BS EN 13601	**Specification for copper for electrical purposes: high conductivity copper rec-tangular conductors withdrawn or rolled edges.**
BS EN 13601	**Specification for copper for electrical purposes. Rod and**
BS EN 12449	**bars 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**

7.3 General

An earthing system generally in accordance with the requirements of IEEE 80 and BS 7430 shall be designed under this Contract. The earthing system shall include earth electrodes to provide the con- nection to the general body of the earth, all earthing 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, back- filling and site testing of earthing systems and connections to electrical apparatus at 400 kV and 230kV substation. Also included is the lightning protection scheme and the provision of portable earth- ing 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 ap- proved 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 resistivi- ties 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 dur-ing 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 sys-tem.

7.6 Fault Current and Duration

Each site shall be provided with an earth grid of buried conductors designed for an earth fault current of 50 kA one second for 400 kV and 230 kV. The preliminary earthing design shall be such that the potential rise shall not exceed 5 kV.

7.7 Earth Electrode System Design

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:

- **earth resistance of the whole system and of its components**
- **earth potential rise**
- **step, touch and mesh potentials inside and outside the perimeter fence**
- **requirements for a high resistance surface layer**
- **conductor ratings**

Earthing points shall be provided such that the combined resistance of the earth grid and all other earthing points does not exceed the allowable limit dictated by the standards for the fault current and duration specified measured during the dry season.

The earth potential rises shall not exceed the CCITT limits appropriate to the classification of the sys-tem 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

7.7.1 Earth Electrode

The earth electrode shall comprise a system of bare conductors forming a mesh buried near the sur- face of the ground and supplemented, if required, by one or more of the following electrodes:

- **a system of interconnected rods driven into the ground**
- **a mesh system of bare conductors buried in the ground**
- **structural metalwork in direct contact with the ground**
- **reinforcing steel in buried concrete**
- **a system of bare conductors buried near the surface of the ground outside the perimeter fence**

7.7.2 Mesh System

The mesh system shall be designed 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 non-linear distribution of the fault current giving rise to the highest potentials at mesh comers.

The rating of the mesh conductors shall be compatible with the fault cur-rents after allowing for parallel paths of hard drawn high conductivity copper strip with a minimum conductor size of 150 mm².

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.

7.7.3 Earthing Rods

If the design calculations show that a mesh alone is unable to limit the potentials to the required val-ues, 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 con- ductor via disconnecting test links.

Individual rods may be connected directly to the mesh, provided the rod can be disconnected for test-ing.

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. As an alternative to rods to supplement a mesh, additional bare copper conductors with a cross-section area of not less than 150 mm² may be used. They shall be buried in the ground within the pe- rimeter 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.

7.7.4 Connection of System Neutrals and Earth

The system neutral points within a substation shall have duplicate connections to the closest earthing point.

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 mm² 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.

7.7.5 Electrical Equipment and Structure Connections to Earth

Connections between: (a) all HV electrical equipment and (b) LV electrical equipment comprising substantial multi-cubicle switchboards and the main earth bar shall be duplicated. The bare copper con- ductor size shall have a minimum cross section area of 240 mm².

All substation equipment, including disconnectors, earthing switches, main transformer tanks, current and voltage transformer tanks, switchgear, electrical supporting steelwork and gantries etc. shall all be connected with the earth grid.

Surge arresters installed for the protection of transformers and reactors shall be connected by low re-actance paths both to the transformer tanks and to the earthing system.

Capacitor voltage transformers used in connection with line traps shall be connected by direct low re-actance paths to a single earth rod for each arrester, in addition to the earth grid.

Where necessary an earthing mat shall be installed at all operating positions for outdoor HV equip-ment 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 cross-section area of 75 mm².

Galvanised structures comprising bolted lattice components shall not be used as the sole earth con- nection path to post and strain insulators or to overhead line earth conductors.

Buildings containing electrical equipment shall be provided, at each level, with a ring of earthing con- ductors which shall have duplicate connections to the earth grid outside the building. The frames of all switchgear, 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 mate- rial as the earth grid. Strip run within buildings, inside cable trenches or above ground level on appa- ratus shall be neatly supported in non-ferrous clamps.

Fixed earthing connectors for use with portable earthing devices specified below shall be provided on each busbar and on both sides of high voltage equipment.

Rigid loops in the copper earthing strip branch bond between the equipment and the earthing grid shall be provided adjacent to each item of high voltage equipment for use with the portable earthing devices. The rigid loops shall be marked green.

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.

7.7.6 Connections to Non-Electrical 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 240 mm².

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 non-conducting building fabric need not be bonded to the main earth bar.

7.7.7 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 mount- ed on a galvanised steel base for bolting to the supporting structure. The two conductors shall be in di- rect 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, glass-filled nylon or other tough non-hygroscopic material for indoor installations.

Fittings not in direct contact with bare or sheathed conductors may be of hot-dip galvanised steel. Bi-metallic 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.

7.7.8 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 exo-thermically welded lugs or a crimped cable socket. The diameter of any holes drilled in strip conduc-tors 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 pro- vided 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 electrical-ly 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 reinforc- ing.

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.

7.8 Lightning Protection

Overhead earthwire shall be provided to protect the equipment from direct lightning strikes. The screens shall be of aluminium clad steel wires of not less than 50 mm². total section, and connected to provide low impedance paths to earth.

The layout of the earth wires shall be such that equipment to be protected generally lies within areas bounded by two or more conductors, in which case the protected angle shall not exceed 45˚. Where equipment is protected by a single earth wire, the protective angle shall not exceed 35˚ to the vertical.

The overhead earthwire shall be suitable for extension to protect the substation equipment to be in- stalled in future stages of development.

7.8.1 Conductors

All conductors used for earthing and bonding the fences and components and for outer rings shall have a cross-sectional area of not less than 70 mm²

Connections shall be made of copper strip of 30mm x 5mm. cross section between the overhead earthed screen wire and the main substation earthing system at each support unless the galvanised steel support structure has sufficient area and current carrying capacity.

Earth wires shall be held in clamps with free pin type joints between clamps and supports.

Connections shall be provided for the terminations of the earth wires of the overhead lines, including bimetal connectors where necessary.

The design of all structures shall generally comply with Section 11 of the specification and in addition is to ensure that in the event of breakage of one earth wire, the Factor of Safety is not less than 1.5.

Quality Assurance, Inspection, Testing, Commissioning and Warranty

8.1 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.

The Employer/Engineer or their designated representatives are entitled to attend the factory ac- ceptance tests, according to clause SCC23 of section-8 of volume-I, which shall be performed at the Manufacturer's works/testing laboratories. Factory acceptance tests shall be performed for the follow- ing equipment:

power transformer 400/230 kV,

The Contractor shall be responsible for bearing the costs for the above mentioned witnessing of factory acceptance tests by two (2)Employer's engineers in each visit, considering visa fees and health in- surance to cover all medical costs that may be required during visit, the return air fare, hotel charges, travelling expensesfrom airport to hotel and hotel to place of testing and return, , together with a per diem allowance of USD 100 for actual working days, excluding travelling time, for each visit and for each of the Employer's Engineers.

For notification of testing, four weeks shall be deemed as reasonable advance notice.

Within 45 days of the letter of acceptance for the contract the contractor shall submit a quality assur- ance programme and a work quality programme for the Engineer's approval.

The Contractor shall have an approved quality management system.

After the award of Contract, the Engineer shall have the right to carry out a review of the quality as- surance procedures operated by the Contractor. The Engineer's review may consider quality assur- ance in relation to the design and manufacture of plant items, but may equally investigate the Contrac- tor's quality assurance procedures for the overall control of the wide range of design activities neces- sary 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 Contractor shall give all necessary help and assistance to the Engineer in carrying out such a quality assurance re- view. The Contractor 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- Contractors' 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 Contractor and his Subcontractors 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 test- ed or inspected. This

process shall continue until a sample proves completely acceptable.

8.2 Subcontracts

Within two months of acceptance of the Bid and in order to facilitate the inspection of bought-out mate- rials and plant, the Contractor shall submit to the Engineer for approval three copies of all sub-orders placed by him as soon as they are issued. One copy of any drawing or schedule referred to in the sub- order shall be submitted simultaneously unless agreed otherwise with the Engineer. Any reference to price may be deleted from the copies so submitted.

The sub-orders 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 Subcontractor's factory.

Sub-orders are to include a statement advising the Subcontractor that the items being ordered will be subject to inspection and test by the Engineer and Employer.

The Contractor shall advise his Subcontractors 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:

Main Contractor's name and sub-order or sub-contract number. Quantities and description of work.

Delivery requirements.

Delivery consignment instructions.

Details of Employer and/or main Contractor's applicable drawing or schedule numbers. Name of the Engineer.

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, Em- ployer and the Contractor.

A reference, particularised in the accompanying Specification, covering the following information:

- **Employer's name**
- **Project title**
- **Contract No.**
- **Engineer's reference number**

Subcontractors shall comply with all the applicable requirements of this Specification and the onus is upon the Contractor to ensure that Subcontractors comply with these requirements.

For the purposes of this clause, interworks orders shall be treated as sub-orders.

8.3 Guarantees

The Contractor 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 Contractor shall further guarantee that all equipment supplied complies with the Contract Docu- ments.

The tolerances permitted in the IEC and British Standards shall apply unless otherwise stated.

8.4 Quality Audit

The quality programme established by the Contractor 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.

8.5 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.

8.6 Inspection Plan and Procedure

The Inspection Plan, as submitted by the Contractor to the Engineer for approval, shall cover the fol- lowing:

Relevant International Standard. For each of the following stages of the work, the acceptance crite-ria shall be stated.

The stages of inspection which shall include but not be limited to the following:

- **Tests to review or approve certification of material;**
- **Review and approval of manufacturing procedures;**
- **Witnessing tests or review and approval of certification of operator's qualification to carry out the work required;**
- **Visual and dimensional examination of components;**
- **Pressure tests on casings and vessels;**
- **Non-destructive examination of materials in progress;**
- **Functional tests on sub-assemblies, performance tests, type tests on complete units;**
- **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.

8.7 Test Certificates

Triplicate sets of all test records, test certificates and curves, whether or not they have been performance witnessed by the Engineer and Employer, shall be Engineer for all tests carried out in supplied to the 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 ref- erence:

Employer's name
Project title
Contract No.
Engineer's reference number

All test documentation shall be in the English language.

8.8 Material Tests

The Contractor shall provide test pieces as required by the Engineer to enable him to confirm the qual- ity 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 Contractor.

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 Con- tractor's or Subcontractor's designers and metallurgists will be consulted before any material is so re- jected.

If the Engineer is furnished with certified particulars of tests which have been carried out for the Con- tractor by the suppliers of material, he may, at his own discretion, dispense with the previously men- tioned tests.

8.9 General Requirements for Tests at Manufacturers' Works

8.9.1 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 Contractor and the whole cost of the repeated tests borne by the Contractor. This also applies to tests carried out at the Subcon- tractors' 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 Contractor and the whole cost of the repeated tests shall be borne by the Contractor. This also applies to tests carried out at Subcontractors' 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 Contractor.

Specific details of tests to be carried out at the Manufacturers' works are defined elsewhere in this Specification.

8.9.2 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 Contractor 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 Contractor, at his own expense, to the entire satisfaction of the Employer.

8.10 Specific Requirements for Tests at Manufacturers' Factories

8.10.1 Pressure Vessels

All pressure vessels shall be designed, fabricated, inspected and tested in accordance with an approved pressure vessel code or standard.
An approved method of radiographic or other non-destructive 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 pro- gramme of non-destructive testing before heat treatment.
Hydrostatic test shall be conducted in accordance with BS 5500.

8.10.2 Substation Automation System, Control, Relay Protection and Meter- ing

All equipment for substation automation system, control, relay protection and metering shall be fully assembled at the Manufacturer's works and subject to the complete routine and functional test

For factory acceptance test all equipment for substation automation system, control, relay protection and metering, for each substation, shall be fully assembled at the Manufacturer's works and subjected to visual and functional tests

All control and relays and associated equipment shall be routine tested to prove the quality and accuracy. Routine tests shall be in accordance with relevant IEC Recommendations supplemented by ad-

ditional 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.

Accuracy of calibrated pick-up and drop-off levels over the effective range of settings Insulation tests
Accuracy of timing elements
Correct operation of flag (or other) indicators
Mechanical requirements, integrity/safety of draw-out units, check of contact pressure and align-ment.

8.10.2.1 WIRING

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 phase-shifting 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.

8.10.2.2Mechanical 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 fit- ting.

Ge neral

Sufficient tests shall be performed on the relays and protection schemes to:

establish that the correct equipment has been supplied and installed.
confirm that the various items of equipment have been correctly interconnected.
confirm performance of schemes designed on the bases of calculation e.g. differential protection.
to provide a set of figures for comparison with future maintenance values allowing the condition of the equipment to be determined.

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 inter- vals.

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.

8.10.2.3 Primary Injection

All current operated relays shall be tested by injection of primary current to record the actual relay set- ting 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 Contractor and the methods employed for a particular installation are to be agreed with the Engineer.

Tests are to be carried out as follows:

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.

Overall primary injection to prove correct interconnection between current transformer groups and associated relays.

Fault setting tests, where possible, to establish the value of current necessary to produce operation of the relays.

8.10.2.4 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.

8.10.2.5 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 fool-proof 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 circuit breaker (or other device) both open and closed.

8.10.3 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 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.

Accuracy of calibrated pick-up and drop-off levels over the effective range of settings Insulation tests
Accuracy of timing elements
Correct operation of flag (or other) indicators
Mechanical requirements, integrity/safety of draw-out units, check of contact pressure and align-ment.

8.10.4 Electrical Instruments and Meters

One instrument and meter of each type and rating shall be subjected to the tests as specified in IEC 60051.

8.10.5 AC Switchboards

Routine tests shall include general inspection and electrical operation tests.

8.10.6 Contactors

One contactor of each type and rating shall be subjected to type tests as specified in IEC 60292-1.

8.10.7 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.

8.10.8 Switchgear (Other than GIS)

All circuit breakers shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-100.

For factory acceptance test one or at least 20% of the circuit breakers of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-100.

8.10.9 Disconnectors and Earth Switches

All disconnectors and earthing switches shall be fully assembled at the Manufacturer's works and sub- jected to routine testes according to the IEC 62271-102.

For factory acceptance test one or at least 10 % of the disconnectors and earthing switches of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-102.

8.10.10 Current and Voltage Transformers

All current transformers and voltage transformers shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60044.

For factory acceptance test three or at least 20 % of the current transformers and voltage transformers of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60044.

8.10.11 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.

8.10.12 Surge Arresters

All surge arresters shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60099-4.

For factory acceptance test three or at least 20 % of the surge arresters of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60044.

8.10.13 Batteries and Battery Chargers

Battery:	**The Contractor 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 ampere-hour 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 ten 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.

8.10.14 Control Panels

Routine operation tests and insulation resistance tests shall be carried out.

8.10.15 Busbars

Routine tests including millivolt drop tests shall be carried out in accordance with the specified stand- ard.

8.10.16 Instruments

Calibration tests shall be witnessed on all important pressure gauges and other instruments as required by the Engineer.

8.10.17 Power Transformers

Inspection and testing during manufacture shall be in accordance with the General Conditions of Contract and this section of the Specification.

Works tests 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 Contractor and the whole costs of the repeated tests borne by the Contractor. This also applies to tests carried out at the Sub- contractors' 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.

All power transformers shall be fully assembled at the Manufacturer's works and subjected to routine testes and special tests

For factory acceptance test all power transformers shall be fully assembled at the Manufacturer's works and subjected to repetition of the all routine testes and special tests

8.10.17.1 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.

Measurement of winding resistance on all tap positions and phases. Ratio, polarity and phase relationship.

Impedance voltage.

Load loss at normal, maximum and minimum taps.

No load loss and no load current at normal voltage Un and at +5% Un and at +10% Un. Magnetising current at nominal voltage Un and at -5% Un and +5% Un and at +10% Un. Insulation resistance.

Dielectric withstand tests:

- **On uniformly insulated windings with highest voltage Um = 36kV, tests shall comprise:**
  - **induced over voltage withstand.**
  - **short duration power frequency voltage withstand.**
  - **full wave lightning impulse withstand for line terminals.**
  - **lightning impulse chopped wave at 115% of the full wave level.**
- **On non-uniformly insulated windings with highest voltage Um 145 W, tests shall comprise:**
  - **induced over voltage withstand combined with partial discharge.**
  - **short duration power frequency voltage withstand.**
  - **full wave lightning impulse withstand for line terminals.**
  - **lightning impulse chopped wave at 115% of the full wave level.**
- **On non-uniformly insulated windings with highest voltage Um = 245kV, tests shall be carried out according to a combination of methods 1 and 2 and comprise:**
  - **short duration power frequency voltage withstand.**
  - **induced line to earth overvoltage withstand test at 460kV (method one routine test).**
  - **full wave lightning impulse withstand for line terminals.**
  - **lightning impulse chopped wave, at 115% of the full wave level.**
  - **induced power frequency overvoltage withstand test with partial discharge measurement. Insulation Resistance**

Type Tests

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. Temperature-rise tests shall be conducted on the tapping corresponding to the maximum losses.

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

Measurement of Zero Phase - Sequence Impedance

The test shall be in accordance with IEC 60076-1 Clause 8.7 and shall be carried out on one transformer of each type.

8.10.17.2 Voltage Control Equipment

Routine Tests

Each finished tap changer shall be subjected to the routine tests specified in JEC.214 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.

8.10.17.3 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.

8.10.18 Outdoor Bushing Assemblies with Porcelain Insulators

Hollow insulators tested in accordance with IEC 60233, complete bushings in accordance with IEC 60137.

Routine Tests

Routine tests shall include:

Oil leakage test

50Hz dry withstand test

Power factor/voltage test

Partial discharge test on all bushings of which the major insulation is either oil impregnated paper or resin impregnated paper.

8.10.19 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 to69 kN/m² or the normal pressure plus 34kN/m² whichever is the greater, for 24 hours during which time no leakage or oil ingress into normally oil free spaces shall occur.

8.10.20 Cooling Plant

Routine Tests

Coolers: Pressure test to be as specified above.

Motors and Control Gear: To the requirements as specified.

8.10.21 Gas and Oil-Actuated Relays

Routine Tests

Oil leakage:When subject to an internal oil pressure of 207kN/m² for fifteen minutes. Gas collection

Oil surge

Performance test under service conditions.Voltage: 2kV for one minute between electrical circuits and casing.

8.10.22 Galvanizing

Routine Tests

To the requirements of BS 443 or BS 729 whichever is applicable

8.10.23 Earthing Transformers

Routine Tests

Measurement of winding resistance

Ratio, polarity and phase relationships

Measurement of impedance voltage

Measurement of loss

Short duration power frequency voltage-withstand test Induced overvoltage withstand test

Insulation resistance of each winding

Special Tests

Measurement of zero-phase sequence impedance

8.10.24 Fibre Optic Multiplexer Equipment

Works tests shall be in accordance with the IEC standard.

8.10.25 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.

8.10.26 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 interfer- ing signals or noise and also the ability not to malfunction (security) in the presence of interfering sig- nals or noise at levels likely to occur when the equipment is installed in the power system substations.

8.10.27 Transducers

Transducers shall be tested in accordance with IEC 60688-1.

8.11 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.

8.12 Inspection and Testing during Site Erection

8.12.1 General

The Contractor 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 Contractor 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 Contractor 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 Contractor in accordance with the General Conditions of Contract. The Contractor 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 Contractor 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 Contractor 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 Contractor shall give sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing programme.

The Contractor 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 Contractor shall record the results of the tests clearly, on an approved form and with clear refer- ence 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 Contractor 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 Contractor's test equipment shall be of satisfactory quality and condition and, where necessary, shall be appropriately calibrated by an approved authority at the Contractor'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 dif- fering 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.

8.12.2 Mechanical Equipment

The extent of testing during erection shall include, but not be limited to, the following:

Checking the accuracy and alignment of plant erected. The accuracy shall comply with the rele-vant 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 Con-tractor.

Checking the alignment of rotating equipment to the Manufacturer's requirements.

Non-destructive testing of site welds as required by the relevant standard and as detailed in this specification.

Hydrostatic testing of pipework systems at a pressure of 1.5 times the design pressure but not less than 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.

Site fabricated tanks and vessels shall be subjected to hydrostatic tests in accordance with the relevant standards.

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 non-drainable sections shall be injected with an oxygen-absorbent chemical and elements plugged.

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 rele- vant 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 Contractor 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 Contractor 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.

Calibration checks on all instrumentation.

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 ship- ping to site.

Other tests as specified which have not been previously conducted.

8.12.3 Electrical Equipment

8.12.3.1 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:

Routine high voltage tests to the appropriate IEC Standard. Where no relevant standard exists, tests shall be agreed with the Engineer.
Insulation resistance tests on all electrical equipment.
Continuity and conductivity resistance tests.
Test operation of alarm and tripping, devices to local and remote. Rotational tests on all motors.
Polarity tests on CTs and VTs. Oil tests.
Grounding system and electrode tests.
Ratio, Vector Grouping and magnetising current tests on each transformer. Calibration of winding and oil temperature devices.
Vector group and phasing tests on VT circuits.
Magnetisation current/voltage tests and winding resistance tests on all current transformers.
Primary and secondary injection tests on relays, protection devices and equipment.

8.12.3.2 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 struc- tures. Checks shall also be made on precautions taken to avoid corrosion. attack on the earthing sys- tem.

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:

of each earth rod after driving
of the earth grid after completion and backfilling of the trenches
of each group of earth rods or earth point after completion of the connection from the test link ter-minal
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 Contractor may also be called upon to provide assistance in the measurement of earth resistance after earth connections to the system have been completed.

8.12.3.3 Control Relays and Metering Panels, Instruments and Protective Devices

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 phase-shifting 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.

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 fit- ting.

General

Sufficient tests shall be performed on the relays and protection schemes to:

establish that the equipment has not suffered damage during transit.

establish that the correct equipment has been supplied and installed.

confirm that the various items of equipment have been correctly interconnected.

confirm performance of schemes designed on the bases of calculation e.g. differential protection.

to provide a set of figures for comparison with future maintenance values allowing the condition of the equipment to be determined.

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 appro- priate relay bus wires with all associated relays, setting resistors, and CT's connected.

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 Contractor and the methods employed for a particular installation are to be agreed with the Engineer.

Tests are to be carried out as follows:

– 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.

– Overall primary injection to prove correct interconnection between current transformer groups and associated relays.

– Fault setting tests, where possible, to establish the value of current necessary to produce operation of the relays.

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.

Tests on Load

Tests on load shall also be done to demonstrate stability and operation of protection relays as re- quired by the Engineer.

All tripping, control, alarm and interlocking circuits shall be functionally tested to prove satisfactory and fool-proof 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 trip- ping 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 meas- ured with the circuit breaker (or other device) both open and closed.

8.12.3.4 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 bat- teries when fully charged shall be recorded.The insulation to earth of the complete DC installation shall be tested.

8.12.3.5 Power Cables

Each completed circuit shall be tested for continuity and insulation resistance.

8.12.3.6 Control and Instrumentation Equipment

The following general tests shall be performed on control and instrumentation equipment at site:

High voltage testing of all circuits, as specified in the relevant IEC or approved standard. Insulation resistance testing of all circuits.

Functional tests of all tripping, control, alarm and interlocking circuits.

The testing of all equipment in accordance with the Manufacturer's instructions or as advised by the Engineer.

8.12.3.7 Transformers and Ancillary Equipment

The following tests shall be performed:

Insulation resistance tests on bushings.

Insulation resistance test at 500V between core and core clamping structure. Voltage withstand tests on insulating oil to BS 148.

Ratio.

Phase relationship.

Magnetisation characteristics of current transformers of winding temperature devices. Calibration of winding temperature devices.

Tap Selector and Diverter Switch alignment.

Calibration of automatic voltage control equipment.

Proving tests as necessary on control schemes.

Measurement of winding resistance on all taps and phases.

Where applicable the above tests shall also be carried out on earthing transformers.

8.13 Staffing

During pre-commissioning the Contractor 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 Contractor's supervisors.

The Contractor 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 Contractor shall provide suitably qualified and experienced operating staff, who shall instruct the Employer's staff in the correct operat- ing procedures.

The Contractor shall provide a team of suitably qualified and experienced engineers and technicians to pre-commission and commission the overall plant. The Contractor 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 Contractor shall ensure that his staff and any Subcontractor's or seconded staff, observe all prescribed safety rules and permit systems.

8.14 Taking Over

After satisfactory completion of the tests on completion, the Engineer will issue a Taking Over Certifi- cate for the plant. The issue of any such certificate shall not however relieve the Contractor of any of his responsibilities in respect of proving that the performance of the plant meets the guaranteed val- ues.
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 Contractor 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.

8.15 Defects after Taking Over

In accordance with the General Conditions of Contract, the Contractor 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 guaran- tee 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 Con- tractor to open up for inspection the whole or any part of the Plant. The Employer will provide the la- bour to work under the direct supervision of the Contractor's representative for the purpose of such in- spection.

The Contractor 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.

8.16 Final Acceptance Certificate

Application for the Final Certificate may be made to the Engineer after the Contractor 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 Taking- Over Certificate has been issued in respect of any Section or Portion of the Works, only one Final Cer- tificate will be issued after all the said obligation has ceased. Final Certificate will be issued after all the said obligation has ceased. Where the Contractor has carried out replacements or renewals to the Works, the Contractor's obligations shall continue, but the right of the Contractor to apply for a Final Certificate other than for the replacements or renewals shall not be affected by that fact.

Power Cables and Cable Terminating Accessories

9.1 Scope

This chapter describes the general technical requirements for the 230 kV power cables & cable terminating accessories and installation of cables and shall be read in conjunction with the project requirements, schedules and drawings in the specification.

The 230 kV cables and accessories shall be suitable for connecting the 400/230/33 kV power transformers with 230 kV AIS switchgear.

The Contractor shall demonstrate that the cables have been designed, built and installed in accord- ance 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 covering all specified tests deemed to be pertinent to the plant and to the conditions in which it will operate at the time of Biding.

The scope of work also includes supply and installation of cable sealing ends at both ends including terminating insulators.

9.2 Standards

The cable and accessories shall comply with this specification and the latest version of relevant IEC, BS or approved equivalent.

9.3 Conditions of Operation

All cables shall be suitable for operation, at the guaranteed continuous ratings specified, throughout all seasons of the year. The nominal system voltage to which the cables will be connected is 230kV and the highest operating voltage Um will be 245kV.

Cable shall be designed to operate continuously at temperature of 90°C. Each conductor and the metal sheath/screen shall be capable of carrying the specified fault current for the specified time and its final temperature shall not exceed 250°C. Adequate measure should be taken to protect against ingress of moisture and water.

Short circuit earth fault rating of cable metal sheath or metallic screen for 230 kV cable shall be 50 kA for 1sec. respectively.

The maximum continuous current carrying capacity and maximum permissible conductor temperature, and the factors for determining such rating and temperature, shall be based on IEC recommendation

No. 287 and subsequent amendments, and all conditions obtaining on Site. The following conditions for the design of the cables shall be assumed:-

Transmission capacity for 230 kV cable circuit: 520 MVA

Other conditions for cables laid in concrete ducts/tunnels/buried pipes shall be assumed:

Max. ambient air temperature:	45°C
Continuous conductor temperature:	90°C
Max. conductor temperature under fault:	250°C

The Contractor shall confirm that the cable sizes are adequate for the required circuit ratings based on the specified foregoing parameters, and he shall also confirm that the cables are adequate for the short- circuit requirements specified. The Contractor will be required to produce cable design calculations to verify that the selected cable sizes are suitable for the selected cable laying conditions in concrete cable ducts, tunnels or buried pipes.

If the Contractor considers that the conditions and the proximity to other power cables, spacing and method of installation are likely to reduce the maximum current carrying capacity he shall increase the cable conductor cross section accordingly.

The conductor section of the cable circuits shall be adequate for carrying the specified short-circuit current when operating under the specified load conditions without deterioration of the dielectric or other component materials of the cable.

9.4 Type Approval

Cables and accessories shall have satisfactorily passed type approval tests in accordance with theSpecificationanddetailsofthecabledesignsofferedshallbegiveninthe Schedule of Particulars and Guarantees. Type test reports shall include cable design details and design drawings of each jointing accessory included in the type test.

The Contractor shall 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 this bid.

The Contractor shall also ensure that all materials used will be subjected to and shall have satisfactori- ly withstood such tests as are customary in the manufacture of the types of cable specified.

Records of such tests shall be available for inspection, if required by the Engineer.

9.5 Cable Lengths

Cables shall be supplied in maximum drum lengths bearing in mind the transport limitations in gaining access to the site. Cables shall be installed in maximum possible lengths and straight through jointing between shorter lengths will not be permitted.

The cable routes on the drawings attached to the Bidding Documents are provided for information only, and it is Contractor's responsibility to establish the exact quantities of cables and accessories required to complete the whole of the works as described in the Specification.

9.6 Cable Drums

Cable drums shall be non-returnable and shall be made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens in accordance with the relevant BS or equivalent IEC standard.

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 Engineer's approval.

Cable maintenance lengths and spare lengths shall be wound on to steel drums before they are hand- ed over to the Employer's stores. Particulars of the cable(as stated above) shall be clearly marked on one flange.

9.7 Spare Cable

In addition to the cable maintenance lengths supplied against the Schedule of Spares the Employer shall have the option to purchase from the Contractor at the rates stated in the Schedule any spare cut lengths of cable for future maintenance purposes.

Brass or other approved sealing caps of the correct size shall be supplied for each end of spare cut cable lengths to enable them to be properly stored for future maintenance purposes. The Contractor shall be responsible for the immediate sealing of such cut lengths and the cost thereof shall be deemed to be included in the contract price.

9.8 Special Tools

Special tools used for the purpose of the cable installation, they shall be handed over to the Employer's stores after the taking over of the installation.

Price for such special tolls is to be considered as included in the price schedule.

9.9 Cable Jointing Instructions and Drawings

Copies of the instructions for the jointing of each type of cable terminating and jointing accessories supplied shall be submitted to the Engineer for approval before any work is commenced at site. One copy of each instruction shall be bound into each copy of the Operating and Maintenance Instructions to be supplied to the Engineer at the completion of the Contract for the use of the Employer.

The following drawings shall be submitted by the Contractor for approval by the Engineer. "As installed" drawings of cable routes shall be drawn to a scale of 1/200. The route shall be dimensioned in such manner that it may be used for pinpointing accurately the cables in the future. All drawings shall be submitted for approval before the issue of the Taking-Over certificate.

9.10 Cable Specification

9.10.1 General

This Specification applies to single core cables with triple extrusion type solid dielectric. They shall be generally manufactured in accordance with the relevant International Electrotechnical Commission Publication (IEC) and British Standard (BS) where applicable.

9.10.2 Conductors

Conductors shall be of stranded plain annealed copper wires to IEC or BS filled to make the cables longitudinally watertight by extrusion during stranding. This shall be to prevent ingress of water into the cable should the outer sheath become damaged. The allowable operating temperature of conductor and waterproofing shall be 90°C.

9.10.3 Conductor Screen

Semi-conductive tape for preventing ingress of semi-conductive XLPE and gluing onto the stranded conductors temperature resistance up to 250°C. Semi-conductive extruded cross-linked material to provide a smooth cylindrical equi-potential surface to which the insulation can be intimately bonded. The material shall be compatible in all respects with its conductor and insulation materials.

9.10.4 Insulation

Cross-liked polyethylene (XLPE) melted together with the conductor screen capable to operate at continuous conductor temperature of 90°C and short circuit temperature of 250°C. Cross-linking process using curing is not permitted, dry process shall be given.The insulation of the completed cable shall be substantially free from voids and contaminants.

9.10.5 Insulation Screen

Semi-conductive compound of extruded layer firmly bonded to the XLPE insulation. The conductor screen, the insulation and the insulation screen are to be extruded in a single process to keep the in- terface smooth.

9.10.6 Metallic Screen

Where the cable core screens are inadequate to meet the earth fault current specified, a metallic layer of adequate cross-sectional area shall be included in the design applied over the screen. The metal-

liclayer shall be Copper screen with counter helix filled with swelling powder sheathed in accordance with latest BS or IEC Publication.

9.10.7 Intermediate Layer

An intermediate layer of suitable compound shall be provided in between metallic screen and aluminium sheath if necessary.

9.10.8 Corrugated Seamless Aluminium Sheath

Metallic sheath shall consist of the extruded corrugated seamless aluminium sheath. Aluminium used for the sheath shall have the minimum purity of 99.5% and shall be of best quality metal free from pinhole flaws and other imperfections. The minimum thickness at any point shall not fall below 85% of the specified nominal thickness by more than 0.1 mm.

9.10.9 MDPE Outer Sheath

After applying the bitumen compound over the aluminium sheath, the extruded MDPE outer sheath shall be applied.

The nominal thickness of outer sheath shall be not less the specified value. The minimum thickness at any point shall not fall below 85% of the specified nominal thickness by more than 0.1mm.

An outer graphite coating shall be applied to outer sheath as an electrode for the voltage test on the extruded outer sheath.

9.10.10 Identification of Cable

The outer PVC sheath of all cables shall carry the following identification marks in three meter intervals approximately.

"Electric Cables- 230000 Volts/33000 Volts and cross section in mm² cu. PGCB, the name of the manufacture and the year of fabrication."

The letters and numerals shall comply with IEC or BS Publication.

9.11 Sealing and Drumming

Immediately after the works tests, both ends of the cable 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. The cable drums shall be arranged to take a round spindle and be lagged with strong, closely fitting so as to take a round spindle and be lagged with strong, closely fitting battens so to prevent damage to the cable. Only steel cable drum shall be used.

The complete cable shall be rolled on steel cable drums capable of withstanding the rough handling during transport without damage of the cable and enabling easy and safe unrolling of the cable during erection.

Each drum shall have marked in indelible point on both flanges, the following indications besides the shipping instructions.

Destination
Type of cable
Exact length
Net and gross
weight Trade mark
An arrow pointing in the direction of unrolling.

9.12 Terminating Accessories

Detailed drawings showing the types of cable sealing ends, terminal boxes and glands proposed for the installation shall be submitted at the time of Bidding. All cable sealing ends and terminal boxes shall be designed with jointing faces below compound level which will ensure the retention of the filling medium and/or cable compound under operating conditions and exclude the entry of air, dust or mois- ture. Cable sealing ends and terminal boxes designed for use with fluid or semi-fluid filling media shall have fanged joints, the faces of which shall be machined.

An earthing strip shall be provided on all boxes terminating lead sheathed cables.

The external dimensions, fixing cables and terminal arrangements for all sealing ends and terminal boxes shall be agreed with the Engineer.

Sealing ends and terminal boxes shall be provided with all necessary fittings, including external flexible connections as required. The design of flexible connections shall be to approval.

Drain plugs shall be of ample size to permit the filling medium to be removed. The contact faces of the cable sockets shall be thoroughly cleaned, the lugs shall be placed in the most suitable positions and arranged as required to avoid unnecessary bending of cable cores inside the box. Provision shall be made for earthing the body of the box, and for expansion of the conductors in the box. Provision shall also be made for the expansion of the filling medium and arrangements made to prevent the formation of air spaces when filling.

9.13 Installation of Cable

9.13.1 Cable Tunnels and Trenches with Pits, Ducts and Drains

The Contractor shall design and construct cable tunnels required for connecting 230 kV power cables. Width and height of cable tunnels shall conform to required cable spacing and working spaces. The structure of cable tunnels is reinforced concrete and must be designed enough bearing capacity cause by some parts of cable tunnel are under heavy equipment.

The Contractor shall design and construct all trenches required for the work. The depth of the cable trenches shall be minimum 1.5 meter from the Substation switchyard, finished level and the width shall conform to required cable spacing and working spaces.

The thickness of cable tunnel or trench wall and floor shall be minimum 150mm and should be designed to withstand the subsoil water pressure.

Cables in cable tunnels or trenches shall be laid on cable supports at every ½ (half) meter interval.

Cable trenches shall be covered with concrete trench covers. Trenches will be built with the top edge of the walls 50mm above the finished switchyard level.

The cable tunnels and trenches shall have a suitable bed slope with sufficient number of drainage pits so that water could be drained off naturally as well as by artificial means.

The removable trench covers shall be of recast reinforced concrete adequately designed to safely with- stand a load of 2,500 N at the centre of each cover. The trench covers shall be of such size as to facilitate their handling by manual labour.

9.13.2 Supports and Racks

Cable laid supports and racks together with fixing clamps, bolts,nuts and screws for outdoor installations and in outdoor concrete lined trenches shall be of hot dip galvanised steel.

Cable support and rack designs shall be submitted for the written approval of the Engineer before Manufacturer or erection.

The single core cables shall be clamped to the racks with smooth finish split packing pieces or cleats with bores of the correct size for the cable diameters. The cleats shall be of Silicon aluminium, glass filled nylon or other tough non-hygroscopic or non-magnetic material. Wooden cleats are prohibited.

9.13.3 Bonding

The cables shall be installed as an insulated sheath system. Single core cable sheaths may either be solidly bonded (single bonding).

Bonding leads shall be of sufficient cross sectional area to carry the maximum imposed short circuit current level. A schematic diagram detailing the proposed bonding systems and stating bonding leads cross section shall be submitted with the Bid.

9.14 Tests

9.14.1 Type Tests

The cable shall be tested and shall satisfy the most recent relevant IEC publications.The tests need not be carried out again if they can be provided by already existing type tests reports of recognized la- boratories.If the cable is not yet type tested, the relevant tests shall be carried out.

9.14.2 Routine/Sample Tests

The cable shall be tested and shall satisfy the most recent relevant IEC Publication.

9.14.3 Tests at Site

After completion of the erection and before commissioning, each cable shall be submitted to the following test:

Verification of the proper and complete erection of the cable and the terminals. Verification of the proper phase displacement.

Verification of the proper earthing of the sheath. DC voltage test.

AC voltage test.

9.15 Earthing System

The cable sheath for single bonding of cable and cable end termination structures shall be earthed at earthing mat by extending the earthing system.

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SECTION 10

BUILDINGS AND CIVIL ENGINEERING WORKS (FOR OUTDOOR GIS & AIS)

10.1 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.

10.1.1 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. Any work essential for proper functioning of the modification project, shall be done by the contractor even if not mentioned in the scope/price schedule. Cost of all these works shall deem to be included within the quoted price. In bay extension/renovation works of existing substation, the contractor should assess the difficulties/obstructions for existing structure and or foundation (shallow or pile) by site visit of the project area. If dismantling of existing foundation is required, then all concrete work below and above ground level (except pile) should be removed. The contractor should deem to the difficulties/obstructions costs within the quoted price. 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:

Performance of site survey and subsoil investigation

Site preparation including site slope protection, cutting or filling up to the level specified in 10.1.4 and levelling as well as compaction.

Foundations for all gantry and equipment to be installed in outdoor switchyards and any other civil works required for the project

Modification of buildings consisting of structural reinforced concrete frames, brick walls, concrete roof and floor slabs.

Internal road including road crossing for cable trench with sufficient drainage pipes, surfacing the entire area within site boundary and surface water drainage.

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, PGCB logo on a separate circular plate to

be fixed at the centre 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:

chain linked fence with gate

internal road

surface water and storm drainage

soak well

lighting, small power, external floodlighting, emergency lighting and fire

protection Chain linked fence as stated in item (a) shall be designed as per enclosed

drawing. Internal road stated in item (b) shall be designed as per enclosed drawings.

10.1.2 Bidder to satisfy himself as to all conditions

The Bidder shall assess:

access conditions at site, plus ground condition and ground bearing capacity

transport costs, materials costs and restrictions of availability of supply of materials locally

importation restrictions and delay due to customs controls

restrictions imposed by existing equipment on sequence of construction, access etc.

restrictions caused by cable laying and overhead line Bidders

ground conditions and temporary works required to provide support during excavation

adjacent distribution substation and their adjacent area of authority if any

availability of permanent bench mark at site

10.1.3 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.

10.1.4 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 600mm above the FGL.

10.1.5 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.

10.1.6.1 Engineer's and Employer's Accommodation/Surveying Equipment

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.

10.1.6.2 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.

10.1.7 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:

- **Issue of approved site survey drawing within the site boundary and up to 15 meters beyond it complete with soil levels and floor levels**
- **Issue of approved electrical layout drawings**
- **Completion of Site Investigation field work**
- **Issue of approved Site Investigation Final report**
- **Completion of loading tests on a foundation on fill site and any other site where settlement is likely to be a problem**
- **Issue of approved drawings required for Planning Permission**
- **Issue of a full complete set of civil building drawings**
- **Construction start date**
- **Date access will be given for:**
  - **Installation of equipment in Buildings**
  - **Installation of outdoor plant**
- **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.

10.1.8 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.

10.1.9 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.

10.1.10 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:

subsoil investigation

every concrete pour and foundation casting

10.1.11 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.

10.2 REFERENCES

10.2.1 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 10.2.2 below.

10.2.2 Design and Construction Standards

BS12	**Portland 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

10.3 DESIGN

10.3.1 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 and all elevations of buildings shall be agreed before other detail plans are prepared.

Air conditioning units shall be provided in rooms listed in Section 13. 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 shall be reinforced by a reinforced concrete frame which shall be capable of resisting a horizontal earthquake force of 0.1G. 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 insitu 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 lime terracing 2:2:7 lime, shurki (powdered brick) and brick chips 0.75" down, which shall be beaten in accordance with local practice or with any other approved water proofing system. The entire roof area shall be laid in one continuous operation. For lime terracing waterproofing system the minimum compacted thickness of terracing shall be 25mm at the low points of the roof with a 1:150 slope to those points formed by a layer of terracing of increasing thickness. Once laid, the terracing shall be covered with a layer of bitumen emulsion and the edge of the terracing shall be protected against erosion into the downpipes. 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 lime terraced 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. Where facing bricks are used below the roof level, they shall also be used above roof level. 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. External walls of other buildings shall be minimum 230mm first class brickwork plus one layer of approved facing bricks 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 3.0 meter and the minimum height of first floor control room shall be 4.0 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.

10.3.2 Ground Conditions, Foundations and Site Investigation

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.

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.

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 10.1.4. The boreholes shall be located to an accuracy of ± 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.

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.

Foundations

Regardless of the result of soil investigation report, the foundations of Main Control Building, gantry structures and auto-transformers shall be provided with piles. Others buildings foundation shall be provided with shallow or pile foundation as per soil condition. 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. But, if width of footing perpendicular to wall exceeds 3000mm, then pile foundation must be provided for boundary walls (refer to enclosed drawing). Stability of surrounding & underlying soil and settlement of the wall foundation must be ensured by the contractor.

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 10.1 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 and one of auto-transformers at each site shall be compression load tested 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.

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:

Blinding depth and projection shall be increased as necessary.

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 bitumastic 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.

10.3.3 Drainage

The entire surface within boundary walls shall be of uniform sloping site, sloping at 1 in 500 minimum slope 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 10.3.18.

The cable trenches will thus form barriers to surface water drainage. If the cutoff 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 bitumastic 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 be sloped at 1:300 minimum.

If a town's water supply is unreliable, the roof rain water shall be collected in an underground tank of standard Employer's design.

10.3.4 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.

10.3.5 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.

10.3.6 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 a deep tube well 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 a 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 of the line terracing 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.

10.3.7 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 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.

10.3.8 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 furnished with non-skid floor tiles 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 verandahs) except for cable basement, GIS room, control room and battery roomshall have 25mm homogeneous floor tiles topping. All external steps where public access is given to buildings shall have marble tiles toppings. Elsewhere, concrete surfaces shall be used for all external floors/steps. Verandahs shall have a minimum 1:50 slope to shed rainwater away from buildings. Concrete floors and steps shall also be treated with 3coats of Lithurin or other approved concrete dust proofer.

Verandahs 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.

10.3.9 Cable Basement

Ground floor of the control room building shall be used as cable floor.

10.3.10 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.

10.3.11 Control Room Floors

No raised floor except for panel installation shall be used.

10.3.12 Site Clearance, Obstructions and Adjacent Structures

The Bidder shall be responsible for clearance of:

Trees, shrubs and any vegetation including the extraction of all roots and compaction of backfill where roots have been extracted.

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.

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.

10.3.13 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.

10.3.14 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.

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.

10.3.15 Doors

Internal doors and door frames shall be anodised aluminium. Main Entrance/Exit doors and door frames shall be steel or anodised aluminium.

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.

10.3.16 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 shall be approved quality and size. Facing bricks 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 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.

10.3.17 Expansion Joints, Joint Fillers and Sealants

Not used.

10.3.18 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 bitumastic 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 soakaways placed at the side of trench; the volume of each soakaway 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.

10.3.19 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 bitumastic 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.

10.3.20 Rainwater Pipes

Down pipes shall be 100mm minimum diameter placed on the outside of walls but enclosed in a brick buttress of facing bricks. 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:

a small open channel conveying the water to the boundary channel

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.

10.3.21 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.

10.3.22 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 bitumastic 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. RCC piles shall be provided below each jacking point to lift the transformer.

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 bitumastic paint.

Skids shall receive 3 coats of bitumastic paint before being cast in.

Adjacent road (perpendicular to rail) shall be extended upto 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.

10.3.23 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.

10.3.24 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,blastwalls

and guard posts shall be painted with a fungicide, Snowcem primer and two coats of Snowcem. All exposed facing bricks 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 bitumastic paint.

All ungalvanized 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, cranebeams, baseplates and holding down bolts and concrete plinths shall receive two coats of bitumastic 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 bitumastic paint.

10.3.25 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.

10.3.26 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 0.13% of gross cross sectional area respectively.

Minimum cover to rebars 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.

10.3.27 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.

10.3.28 External Render

All brickwork which is not faced with facing bricks shall be rendered. Concrete columns and walls shall be rendered and painted in accordance with BS 5262 with a 3mm spatterdash 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.

10.3.29 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 11 of this Contract for the high voltage switchgear.

10.3.30 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.

10.3.31 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 (38mm dia. for vertical railing & 50mm dia for horizontal railing).

All roofs which are not accessible by stairs shall be provided with a galvanised steel fixed ladder.

10.4 CONCRETE WORKMANSHIP

10.4.1 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.

10.4.2 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 (Colormetric test) and ASTM. C33-82.

10.4.3 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.

10.4.4 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.

10.4.5 Cement

Ordinary Portland Cement shall comply with BS 12A. 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. 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.

10.4.6 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.

10.4.7 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.

10.4.8 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.

10.4.9 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.

10.4.10 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:

Formwork coated with mould oil and correct in type, quantity and condition

Centre lines of template to coincide at the centre peg

Formwork to be well strutted and correctly located

Vibrator to be in working order

Mixer to be in working order

There is provision to maintain continuous mixing and pouring, by hand if necessary, in the event of a mixer breaking down

Where necessary, re-bar is on site ready bent and complete with tie wire, stirrups and concrete or plastic preformed spacer packs

A reliable level is at hand

There is sufficient aggregate, cement and water to complete the pour

Excavations are safe and not cluttered around the top edges

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

A suitable chute is in place

Both an air thermometer and concrete thermometer are on site

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.

10.4.11 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.

10.4.12 Formwork

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. At all unexposed surfaces and rough work, undressed timber may be used. Timber reused in shutters shall have nails withdrawn and surfaces to be in contact with concrete thoroughly cleaned before being reused. 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.

10.4.13 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.

10.4.14 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.

10.4.15 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.

10.4.16 Hot Weather Concreting

In hot weather the following additional precautions shall be taken.

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.

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.

10.5 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.

10.6 Land development work:

10.6.1 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:

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 Proctor Test.

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 Proctor Test.

10.6.2 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.

10.6.3 Before land filling, The Contractor has to construct necessary dyke/embankment for protection the developed land.

10.6.4 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.

10.6.5 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.

10.6.6 The Contractor is responsible to obtain the permission/approval from the competent authority for the works as mentioned in clause no. 4 & 5 above.

10.6.7 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.

10.6.8 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.

10.6.9 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.

10.6.10 The Contractor will arrange the testing of the samples of the fill materials & compaction tests of developed areas by Laboratory approved by employer. The cost of any or all such tests shall be borne by the Contractor.

10.6.11 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.

10.6.12 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.

10.6.13 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.

10.7 Fire Extinguisher:

10.7.1 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.

10.7.2 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, non toxic. 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	**5Nos.**
	5kg	**5 Nos.**
2	**ABC dry powder type:**	
	5kg	6 Nos.
	8kg	4 Nos.
	15kg(including wheel carriage)	3 Nos.
3	Sand bucket with metal frame	One(1)set with 5 buckets

ANNEXURE-10.1

DETERMINATION OF DEPTH OF FIXITY, LATERAL DEFLECTIONAND MAXIMUM MOMENT OF LATERALLY LOADED PILES

10-1. DETERMINATION OF LATERAL DEFLECTION AT THE PILEHEAD AND DEPTH OF FIXITY

10.1.1 The long flexible pile, fully or partially embedded, is treated as a cantilever fixed at some depth below the ground level (see Fig. 2).

10-1.2 Determine the depth of fixity and hence the equivalent length ofthe cantilever using the plots given in Fig. 2.

Where $T = \left(\frac{EI}{K_1}\right)^{\frac{1}{5}}$

(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.

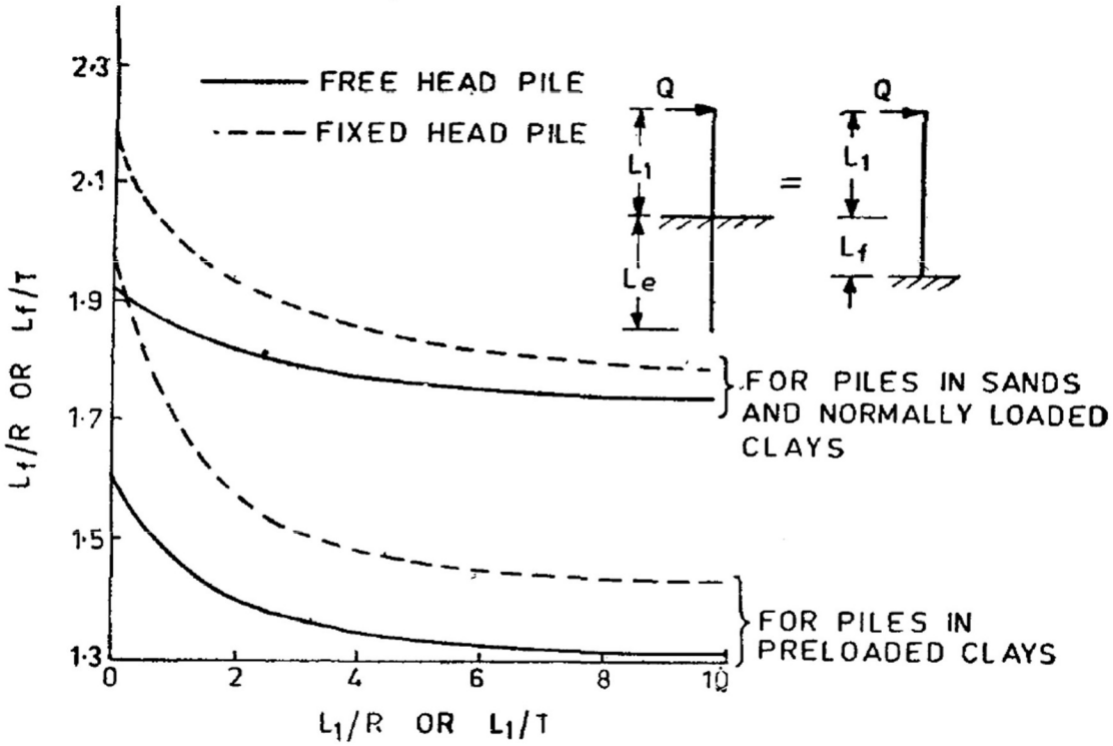


FIG. 2 DETERMINATION OF DEPTH FIXITY

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.

10.1.3 Knowing the length of the equivalent cantilever the pile head deflection (Y) shall be computed using the following equations:

$$Y = \frac{Q(L_1 + L_f)^3}{\quad}$$

… ..... 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

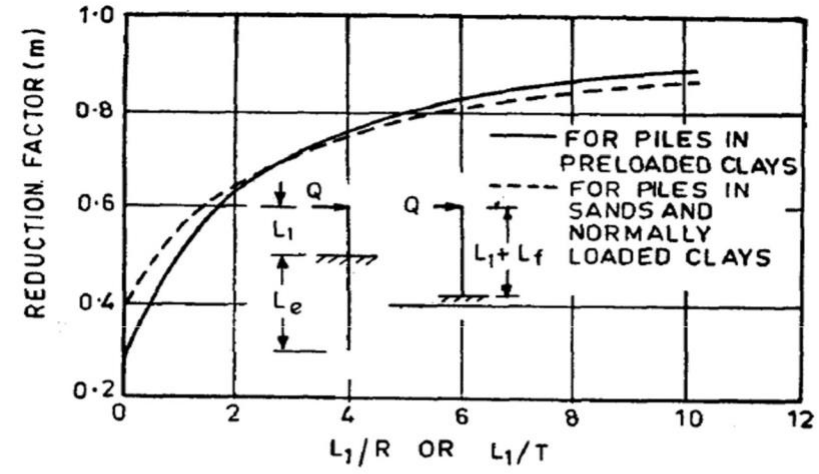
10.2. DETERMINATION OF MAXIMUM MOMENT IN THE PILE

10.2.1 The fixed end moment (M_F) 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:

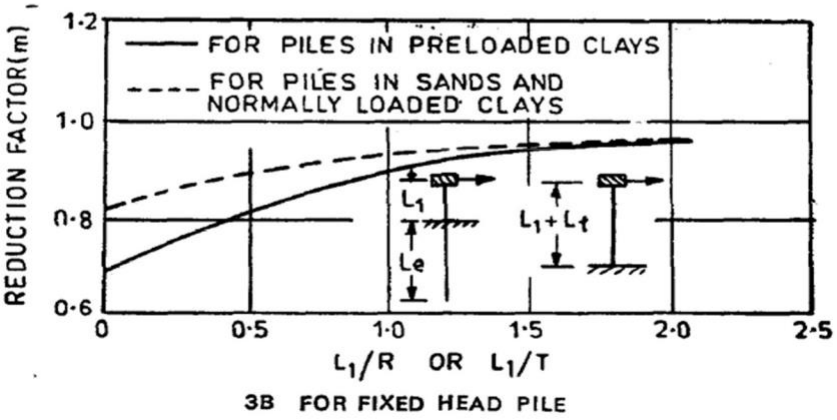
$M_f = Q(L_1+L_f)$ **.....for free head pile**

$= \frac{Q(L_1+L_f)}{2}$ **… .....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

10.2.2 **Reinforcement of upper section of pile should be provided upto 1.25x L_f depth**

SECTION 11

SUPPORTING STRUCTURES FOR OUTDOOR EQUIPMENT

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SECTION 11

SUPPORTING STRUCTURES FOR OUTDOOR EQUIPMENT

11.1 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.

11.2 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 Aluminium as specified. For lattice structures a fully triangulated system of bracings shall preferably be adopted. For A-frame structures theprimary 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 andlow level structures shall be as specified in the Schedule of Technical Requirements.

11.3 DESIGN

11.3.1 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.

11.3.2 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)

The wind pressure specified in the Schedule of Technical Requirements Appendix 11 of this Section, applied to the projected area of all conductors and electrical equipment;

The wind pressure specified in the Schedule of Technical Requirements applied to the projected area of all members of the windward face of structure;

Where appropriate the conductor and/or earthwire tensions or busbar forces, including due allowance for both horizontal and vertical deviations /inclinations;

Self weight of the equipment and structure;

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

Conductor and/or earthwire tensions or busbar forces including the dynamic affects calculated in accordance with IEC 865-1.

Self weight of the equipment and structure;

Unless agreed to the contrary, the "resultant spring constant" (s) of both supports of one span for strained conductors shall be taken as 10^7 N/m for steel structures.

Load Combination 3 - Still Air, Seismic, Coincident Temperature (Ice)

Conductor and/or earthwire tensions or busbar forces;

Seismic forces;

Self weight of the equipment and structure;

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 theconductor, earthwire, busbar, electrical equipment and structure, and applied at the centre of gravity of the equipment and structure as appropriate.

Load Combination 4 - Still Air, Erection, Coincident Temperature

Conductor and/or earthwire tensions or busbar forces;

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.

11.3.3 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.

11.3.4 Partial Load Factors

The partial load factors to be applied to the loading combinations determined in accordance with Clause 11.3.2 shall be as specified in the Schedule of Technical Requirements.

11.3.5 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 levelshall 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 x 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.

11.3.6 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 ofthe 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.

11.3.7 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 notmore 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 specifiedcage 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.

11.3.8 Structural Design

The allowable ultimate unit stresses used in the determination of the nominal memberstrength of supporting structures shall be based on the following:

Lattice steel structures	ANSI/ASCE 10-90
Steel A frame or moment structures	BS 5950
Aluminium structures	BS 8118: Part I

Partial factors to be applied to member nominal strength determined in accordance with theabove 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 /Aluminium
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.

11.3.9 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.

11.3.10 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.

11.4 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.

11.5 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 aluminium structures. All members shall be stamped on before galvanising or other protective coatings, using characters 10mm high and shall be clearly legible after galvanising.

11.5 PROTECTIVE TREATMENT

Unless otherwise specified after fabrication, all structural steelwork, including bolts, nuts and washers shall be hot dipped galvanised 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 galvanised 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 aluminiurn shall be in accordance with the requirements of BS 8118.

Galvanising thickness and aluminium protection procedure shall be as specified in the Schedule of Technical Requirements

11.6 QUALITY CONTROL

11.6.1 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/aluminium 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.

11.6.2 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.

11.6.3 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 withoutextraordinary effort to align bolt holes, or to force pieces into position. Bolt holes shall not bereamed 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.

11.6.4 Galvanising

Tests on galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS 729.

11.6.5 Tolerances

The fabrication tolerances after galvanising for steel members, which are not to be considered cumulative shall be as follows:

On linear dimensions of nominal sections as per BS 4, BS 4848, BS EN 10024, BS EN10034 & BS EN 10056-2.

(b) On overall length of member ± lmm

(c) On centres of holes ± lmm

(d) On groups of holes ± 2mm

On back-gauges± lmm

(f) On corresponding holes in opposite faces of a member ± lmm

(g) On specified hole diameter on the punch side (in the black), ± 0.3%

or when drilled -0mm

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) ± l.0mm

(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.

11.7 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 11

Line	Description			
1.	Structure Arrangement [clause 11.2]			
	High Level		Lattice or A-Frame	
	Low Level		Lattice or Moment	
	Primary Material		Steel	
2.	Load Combination 1 [clause 11.3.2]		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 11.3.3]		Phase	Earthwire
	Conductor Designation		Finch	7 x 4.0
	Type		ACSR	GSW
	Number of sub-conductors		2	-
	(All of the above three shall be finalized during execution)			
	Maximum working tension per Phase (132kV)	kN	14	4.5
	Maximum working tension per Phase (230kV)	kN	20	5.0
	Maximum working tension per Phase (400kV)	kN	40	5.0
	Wind pressure	kN/m2	1.40	1.76
	Radial ice thickness	mm	0	0
	Maximum downlead span	m	75	75
	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	-
	Partial Load Factors [clause 11.3.4]		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 11.3.7]			High Level	Low Level
	Step bolts			YES	NO
	Ladders:			YES	NO
	Cage protection			NO	NO
	Fall arrest system			NO	NO
	Partial Material Factors [clause 11.3.8]				
	Steel			0.85	
	Aluminium			-	
	Foundations			0.76	
7.	Minimum Member Thickness [clause 11.3.8]			Steel	Aluminium
	Main member	mm		6.0	
	Other bracing members	mm		5.0	
	Secondary (redundant) members	mm		5.0	N/A
	Plates	mm	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	
	Protective Treatment [clause 11.6]				
	Galvanising thickness	µm		85	N/A
	Protection procedure			BS 729	No

Fibre-Optic Multiplexer Equipment for Communication and Protection

12.1 Scope of Specification

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) in Rampura, 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 current differential protection of the 400kV, 230kV & 132kV 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'snetwork, including the telecommunication network management system. The fibre optic multiplexeres presently used in PGCB's network are:

ABB FOX 515/615, and
Areva MSE 5001

The Manufacturer of Telecommunication system – Fibre optic multiplexer equipment for communication and protection shall be: ABB (Switzerland), GE (former Alstom/Areva) , ZTE/HUAWEI (China).

Only Manufacturer Authorization Letter is required to be submitted with the bid. Since, above mentioned manufacturers are approved, all other requirements mentioned in sub-clause 2.7. of Section 3 of Volume 1 are not required.

Any other Manufacturer of Telecommunication system shall have to fulfil the Qualification Criteria required in sub-clause 2.7. of Section 3 of Volume 1 of Tender documents

12.2 Summary of Standards

The Equipment shall comply with the latest ITU-T recommendations for the plesiochronuous and synchronous hierarchies.

The equipment shall be KEMA type tested.

12.2.1 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**
TU-T G.826	**Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate**

12.2.1 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

12.2.1 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.	Synchronisation Layer Functions
1.2 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)

12.3 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**
VF	**Voice Frequency**

12.4 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 and 2Mbit/s HDSL interfaces shall be available. In addition, optical STM-1 aggregate interfaces on 155Mbit/s 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

X.24/V. 11 (RS-422), Nx 64kbit/s data
interface V.24/V.28 (RS-232), data interface
RS 232/485/422 dat 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
/ 2 Mbit/s HDSL interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

12.5 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 Mbit/s), second order multiplexing (8448 Mbit/s/s) and STM-1/STM- 4 or STM-16 (for 400kV if any) 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.

12.5.1 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.

12.5.2 Redundant Centralised Functions

The equipment shall be equipped with redundant circuits for all centralised functions.

12.5.3 Power Supply

The multiplex equipment shall operate at 48VDC +/- 15%. Redundant power-supply shall be supported.

12.5.4 ITU Compliance

The Equipment shall comply to the latest ITU-T recommendations for the plesiochronuous and synchronous hierarchies, such as:

G.702-704, G.706, G.711-714, G.732, G.735-737, G.742, G.826, G.823, Q-552

12.5.5 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.

12.5.6 Ambient Conditions

Storage and transport:	**-40... +70˚C; 98% (no condensation)**
Operation:	**-5... +45˚C, humidity of max. 95% (no condensation)**

12.5.7 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.

12.5.8 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 and SDH equipment.

12.5.9 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.

12.5.10 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.

12.5.11 Network Topology

It shall be possible to build point to point, linear, ring, T, and meshed networks.

12.5.12 Synchronisation

The equipment shall be synchronisable with an external centralised clock, with connected 2048 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.

12.5.13 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.

12.5.14 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.

12.5.15 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.

12.6 Requirements for Transport Level

12.6.1 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

12.6.2 HDSL Aggregate Units

2Mbit/s HDSL interface

The HDSL interface shall provide means to interconnect the multiplexer over two pairs of copper wire up to 12km using CAP modulation (Carrier-less Amplitude and Phase). It shall communicate either with another interface of the same type or with a remote desktop terminal.

2Mbit/s HDSL Desktop Terminal

This Terminal shall provide a HDSL interface to transmit 2Mbit/s over two pairs of copper over a distance up to 12 km.
It shall be housed in a metallic indoor case. The following interfaces shall be available:

G.703, 2Mbit/s, 75 ohm
G.703, 2Mbit/s, 120 ohm
X.21/V 11, Nx 64kbit/s (N = 1 ..
32) V.35, Nx 64kBit/s (N = l.. 32)
V.36 / RS485, Nx 64kbit/s (N = l.. 32)

12.7 LAN Connection:

l/0 base ethernet connection for e.g. router supporting LAN protocols: IP, IPX; routing protocols: RIP; WAN protocols: HDLC, PPP, frame relay (including RFC 1490). It shall inter-operate with Cisco, Wellfleet, 3Com etc. and be manageable locally, remotely, and with Telnet and SNMP. Two such desktop terminals shall be connectable to provide a 2Mbit/s link over two pairs of copper.

12.8 HDSL Repeater:

An HDSL repeater solution for distances longer than 12km shall be offered including a remote powering solution.

12.8.1 HDSL Line Protection:

The HDSL equipment shall (where necessary) be protected against influences of induced voltages up to 10 kV.

12.9 Tributary Units

12.9.1 4-Wire Interface (VF Interface)

This interface shall provide 8 voice channels with a bandwidth of 300 Hz to 3.4 kHz and 2 signalling channels (M => E, M' => E') per voice channel.

Each interface shall be configurable to operate with or without CAS. With CAS it shall use the a and b bits for the two signalling channels.

The level shall be software adjustable within the following range:

Input: +7.5 to -16 dBr
Output:+7.0 to -16 dBr

Modules where each interface can be individually configured with 1+1 path protection shall be available.

12.9.2 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

12.9.3 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

12.9.4 Party Line Telephone System (Engineering Order Wire)

An engineering order wire (EOW) facility shall be provided at each multiplexer. The EOW shall be configured as a party line and use in band DTMF signalling to call another EOW-Terminal. The terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (LA digits), and two group call numbers (LA digits each).

12.9.5 V. 24N.28 RS232 Interface

It shall support the following bit rates:

0 ... 0.3 kbit/s transp. (V. 110)
0.6 ... 38.4kbit/s synchronous / asynchronous (V. 110).

Modules where each interface can be individually configured with 1+1 path protection shall be available.

12.9.6 V.11/X.24 Interface

This interface shall comply to the ITU-T X.24 recommendation for signal definition and to V. 11 for electrical characteristics.

It shall support the following bit rates:

48, 56, Nx 64 kbit/s (N = 1 ... 30) synchronous
0.6 ... 38.4kbit/s synchronous / asynchronous (X.30)

Modules where each interface can be individually configured with 1+1 path protection shall be available.

12.9.7 V.35 Interface

~~**This interface shall comply with the ITU-T V.35 and V. 110 recommendations. It shall support the following bitrates:**~~

~~**48, 56, Nx 64kbit/s (Nx = 1... 30) synchronous**~~
~~**0.6 ... 38.4kbit/s synchronous / asynchronous**~~

Modules where each interface can be individually configured with 1+1 path protection shall be available.

12.9.8 V.36 / RS 485 Interface

~~**This interface shall comply with the ITU-T V.36 and V. 110 recommendations. It shall support the following bit rates:**~~

~~48, 56, Nx 64kbit/s (N = 1... 30) synchronous~~
~~0.6 ... 38.4kbit/s synchronous / asynchronous~~

Modules where each interface can be individually configured with 1+1 path protection shall be available.

12.9.9 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.

12.9.10 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.

12.9.11 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.

12.9.12 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.

12.9.13 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.

12.9.14 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.

12.9.15 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.

12.10 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.

12.11 Communications DC Power Supply Equipment

12.11.1 General

12.11.1.1 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 batteryshall 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.

12.11.1.2 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 theoutput 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.

12.11.2 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.

12.11.3 Charger

12.11.3.1 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.

12.11.3.2 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.

12.11.3.3 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.

12.11.3.4 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.

12.11.3.5 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.

12.11.3.6 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.

12.11.4 Battery

12.11.4.1 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:

Sec-14: Fibre Optic Multiplexer

- **Manufacturer's reference number and**
- **code year and month of manufacture**
- **voltage and nominal capacity at the 10 hour**
- **rate cell number.**

12.11.4.2 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.

12.11.4.3 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.

12.11.4.4 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.

12.11.4.5 Capacity

The battery capacities shall be 200 ampere hours at the 10 hour rate.

12.11.5 D.C. Distribution and Instrumentation

12.11.5.1 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.

12.11.5.2 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.

12.11.6 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 theload. 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.

MADUNAGHAT–1
REACTOR BAY–1
MADUNAGHAT–2
REACTOR BAY–2
UNIQUE PP
AMINBAZAR–1
AMINBAZAR–2
FUTURE
FUTURE
FUTURE
(SEE NOTE – 4)
(SEE NOTE – 8)
400kV MAIN BUS–I
5000A, 50HZ, 50kA FOR 1Sec.
400kV MAIN BUS–II
5000A, 50HZ, 50kA FOR 1Sec.
RELIANCE PP–1
RELIANCE PP–2
SUMMIT PP
400/235/33KV, 500/750MVA, AT#1 3PH, YNaOd1
400/235/33KV, 500/750MVA, AT#2 3PH, YNaOd1
400/235/33KV, 500/750MVA, AT#3 3PH, YNaOd1
HV BCT 1200/1/1A 5P20, 60VA
HV NCT 1200/1/1A 5P20, 30VA
BCT–3 630/1/1/1A, 5P20/0.2/5P20, 30VA
BCT–2 CORE–1: 2000/1A, 5P20, 60VA CORE–2: FOR WTI
(SEE NOTE – 5)
(SEE NOTE – 10)
33/0.412KV, 500KVA, ST#1 3PH, ZNyn11
33/0.412KV, 500KVA, ST#2 3PH, ZNyn11
TO LVAC SYSTEM
ICT BAY – 1
ICT BAY – 2
ICT BAY – 3
400kV SWITCHYARD
230kV SWITCHYARD
T/L
110Vdc
220Vdc
CONTROL VOLTAGE
(ICT BAY_03)
FUTURE ICT BAY
FUTURE ICT BAY
NEW 230KV SUBSTATION
EXISTING 230KV SUBSTATION
SHYAMPUR–2
SHYAMPUR–1
HARIPUR–1
HARIPUR–2
shyampur 1
shyampur 2
Vr=216KV
230kV MAIN BUS–I 1600A, 40KA (EXISTING)
230kV MAIN BUS–II 1600A, 40KA (EXISTING)
230kV MAIN BUS–I 3000A, 50HZ, 50kA FOR 1Sec.
230kV MAIN BUS–II 3000A, 50HZ, 50kA FOR 1Sec.
Ir=3000 A
Ir=3000/1A
Ir=2400-1600/1A
Ir=3150 A sc=50KA/1 sec
SMPCL–1
SMPCL–2
GEN (GT2) TRANSFORMER
GEN (GT1) TRANSFORMER
START–UP TRANSFORMER
GEN (ST) TRANSFORMER
COMILLA NORTH–2
COMILLA NORTH–1

LEGENDS:

- UNDER PRESENT SCOPE
- FUTURE
- EARTH SWITCH (ES)
- HCB DISCONNECTOR (89)
- CURRENT TRANSFORMER (CT)
- CAPACITIVE VOLTAGE TRANSFORMER (CVT)
- INDUCTIVE VOLTAGE TRANSFORMER (IVT)
- SURGE ARRESTER (LA)
- WAVE TRAP (WT)
- AUTO-TRANSFORMER (AT) / INTER-CONNECTING TRANSFORMER (ICT)
- STATION TRANSFORMER (ST)
- SHUNT REACTOR

ANNEXURE_B
TENDER PURPOSE DRAWING

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SCOPE OF WORK

NOTES:

1. BCT core, ratio shall be exactly the same as existing ATR
2. FOR EQUIPMENT BOQ, SYSTEM PARAMETERS AND CT, PT DATA REFER SHEET 2 OF 2 OF THIS DRAWING.

REFERENCE DRAWINGS:

1. SINGLE LINE DIAGRAM OF 400/230KV MEGHNAGHAT AIS SUBSTATION
2. KEY SINGLE LINE DIAGRAM 230KV SWITCHYARD

Employer's Approval Stamp

Rev.	Rev. Date	Modification	Drawn By	Created By	Approved By
E	2020.02.18	REVISED BASED ON NEW 400KV BAY ALLOCATION	MR	PKD	SB/TB
D	2020.01.24	REVISED AS PER CLIENT'S COMMENT DATED 12/01/20	MR	PKD	SB/TB
C	2019.12.17	REVISED AS PER CLIENT'S COMMENT DATED 12/12/19	MR	PKD	SB/TB
B	2019.12.04	REVISED AS PER CLIENT'S MAIL DATED 06/11/19.	MR	PKD	SB/TB
A	2019.10.30	REVISED AS PER CLIENT'S COMMENT DATED 04/09/19.	MR	PKD	SB/TB
0	2019.07.24	FIRST SUBMISSION	MR	PKD	SB/TB

Drawing/Document Number: PGCB-MEG-400/230KV-SLD-001
Customer: POWER GRID COMPANY OF BANGLADESH LTD. ,
Consultant:
Project:
LOCATION: MEGHNAGHAT
SUB STATION TYPE: AIS SUBSTATION
VOLTAGE LEVEL: 400/230kV
Purpose of Submission: PRELIMINARY; ENGINEERING APPROVAL; CONSTRUCTION

Scale	Paper Size	Sign.	Date	LOI No.:
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	Created By		2019.07.24	Title: SINGLE LINE DIAGRAM FOR 400/230KV SWITCHYARD, MEGHNAGHAT
	Approved By		2019.07.24	

Document Designation
Document Tree

Rev.	Date of Issue	Language	Sheet
F		EN	1 of 2

BOQ – 420kV EQUIPMENTS EXCEPT FOR REACTOR BAYS (50kA FOR 1 SEC.)			MAIN PACKAGE			SUMMIT PP			RELIANCE PP			UNIQUE PP		
SYMBOL	LEGEND	DESCRIPTION	LOCATION	QTY.	UNIT	LOCATION	QTY.	UNIT	LOCATION	QTY.	UNIT	LOCATION	QTY.	UNIT
	52	420kV, 4000A, 3PH, 50 KA/1SEC, 50HZ, 1425KVp BIL, SINGLE POLE OPERATION, SF6 GAS CIRCUIT BREAKER WITH CSD	408–52, 409–52, 410–52, 411–52, 412–52, 413–52, 414–52 418–52 417–52	2	SETS	415–52*	1	SET	403–52* 406–52*	2	SETS	407–52*	1	SET
	52	420kV, 4000A, 3PH, 50 KA/1SEC, 50HZ, 1425KVp BIL, SINGLE POLE OPERATION, SF6 GAS CIRCUIT BREAKER WITH PIR	401–52, 404–52	1	SETS									
	52	420kV, 4000A, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, SINGLE POLE OPERATION, SF6 GAS CIRCUIT BREAKER WITH CSD & PIR	405–52	1	SET				402–52*	1	SET			
	89	420kV, 4000A, 3PH, 50 KA/1SEC, 50HZ, 1425KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS WITH MOTOR OPERATED EARTHING SWITCH	401–89L, 404–89L, 410–89L, 413–89L	4	SETS	415–89L*	1	SET	403–89L* 406–89L*	2	SETS	407–89L*	1	SET
	89	420kV, 4000A, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS WITHOUT EARTH SWITCH	401–89A, 401–89B, 404–89A, 404–89B, 405–89A, 405–89B, 408–89A, 408–89B, 409–89A, 409–89B, 410–89A, 410–89B, 411–89A, 411–89B, 417–89A 417-89B • 418-89A • 418-89B	4	SETS	415–89A* 415–89B*	2	SETS	402–89A*, 402–89B*, 403–89A*, 403–89B*, 406–89A*, 406–89B*,	6	SETS	407–89A* 407–89B*	2	SETS
	89	420kV, 2000A, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS	409–89T, 412–89T 418-89T	1	SETS									
	ES	420KV, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, MOTOR OPERATED BUSBAR EARTHING SWITCH	400–ES1, 400–ES2	2	SETS									
P2 P1	CT	1PH, 6 CORE, 420KV, 50KA/1SEC, –, 50HZ, 1425KVp BIL, CURRENT TRANSFORMER 4000-2000/1	401–CT, 404–CT, 405–CTA, 405–CTB, 408–CTA, 408–CTB, 409–CT, 410–CT, 411–CTA, 411–CTB, 418 –CT, 417–CTA, 417 –CTB	09 (= 3x3)	NOS.	415–CT*	3 (=1x3)	NOS.	402–CTA*, 402–CTB*, 403–CT*, 406–CT*	12 (=4x3)	NOS.	407–CT*	3 (=1x3)	NOS.
	CVT	1PH, 3–WINDING, 420KV, 50KA/1SEC, 50HZ, 1425KVp BIL, 5000pF CAPACITIVE VOLTAGE TRANSFORMER	401–CVT, 404–CVT, 409–CVT, 410–CVT, 412–CVT, 413–CVT 400–CVT1, 400–CVT2 418-CVT	3 (= 1x3)	NOS.	415–CVT*	3 (=1x3)	NOS.	403–CVT*, 406–CVT*,	6 (=2x3)	NOS.	407–CVT*	3 (=1x3)	NOS.
	LA	1PH, 390KV RATED VOLTAGE, 303KV(RMS) CONTINUOUS OPERATING VOLTAGE AT 50°C, 10KA, 50HZ, HEAVY DUTY STATION CLASS, METAL OXIDE TYPE, SURGE ARRESTER	401–LA, 404–LA, 409–LA, 410–LA, 412–LA, 413–LA 400–LA1, 400–LA2, 400–LA3, 400–LA4 418-LA	3 (= 1x3)	NOS.	415–LA*	3 (=1x3)	NOS.	403–LA*, 406–LA*,	6 (=2x3)	NOS.	407–LA*	3 (=1x3)	NOS.
	WT	WAVE TRAP (1PH, 420KV, 420KV, 4000A, 1mH)	401–WT, 404–WT, 410–WT, 413–WT	8 (=4x2)	NOS.							407–WT*	2 (=1x2)	NOS.

BILL OF QUANTITY – 420kV EQUIPMENTS FOR REACTOR BAYS (50kA FOR 1 SEC.) (SEE NOTE – 4)					
SYMBOL	LEGEND	DESCRIPTION	LOCATION	QTY.	UNIT
	52R	420KV, 2000A, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, SINGLE POLE OPERATION, SF6 GAS CIRCUIT BREAKER	401–52R, 404–52R	2	SETS
	89R	420KV, 2000A, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS WITH MOTOR OPERATED EARTHING SWITCH	401–89R, 404–89R	2	SETS
	RX	400KV, 40MVAR (ONAN), 3PH, OUTDOOR TYPE SHUNT REACTOR (RATING OF SHUNT REACTOR WILL BE AS PER EMTP STUDIES. BCT & NCT WILL BE SELECTED ACCORDINGLY.)	401–RX, 404–RX	2	SETS
	LAR	1PH, 390KV RATED VOLTAGE, 303KV(RMS) CONTINUOUS OPERATING VOLTAGE AT 50°C, 10KA, 50HZ, HEAVY DUTY STATION CLASS, METAL OXIDE TYPE, SURGE ARRESTER (THEY ARE NOT IN CURRENT BPS OF SUPPLY.)	401–LAR, 404–LAR E	6 (=2x3)	NOS.

BILL OF QUANTITY – TRANSFORMERS					
SYMBOL	LEGEND	DESCRIPTION	LOCATION	QTY.	UNIT
	AT	400/235/33kV, 500/750MVA (ONAN/ONAF), 3PH AUTO TRANSFROMER	AT#1, AT#2 AT# 3	1	NOS.
	ST	33/0.412kV, 500KVA, 3PH EARTHING/AUXILIARY TRANSFROMER	ST#1, ST#2	2	NOS.

BILL OF QUANTITY – 245kV EQUIPMENTS (50kA FOR 1 SEC.)					
SYMBOL	LEGEND	DESCRIPTION	LOCATION	QTY.	UNIT
G	52	245KV, 3150A, 3PH, 50KA/1SEC, 50HZ, 1050KVp BIL, GANG OPERATED, SF6 GAS CIRCUIT BREAKER	093–52, 092–52, 083–52, 082–52, 200–52A, 200–52B 143-52	1	SETS
SP	52	245KV, 3150A, 3PH, 50KA/1SEC, 50HZ, 1050KVp BIL, SINGLE POLE OPERATION, SF6 GAS CIRCUIT BREAKER	091–52, 081–52 862B 865B 868B	3	SETS
	89	245KV, 3000A, 3PH, 50KA/1SEC, 50HZ, 1050KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS WITH MOTOR OPERATED EARTHING SWITCH	143-89L, 231S-232G	2	SETS
	89	245KV, 3000A, 3PH, 50KA/1SEC, 50HZ, 1050KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS WITHOUT EARTHING SWITCH	143-89T, 861S, 863S, 864S, 866S, 867S, 869S,	7	SETS
	89	245KV, 2000A, 3PH, 50KA/1SEC, 50HZ, 1050KVp BIL, ELECTRICALLY GANGED, MOTOR OPERATED HDB DISCONNECTORS WITHOUT EARTHING SWITCH	093–89T, 083–89T	2	SETS
	ES	245KV, 3PH, 50KA/1SEC, 50HZ, 1425KVp BIL, MOTOR OPERATED BUSBAR EARTHING SWITCH	200–ES1, 200–ES2	2	SETS
P2 P1	CT	1PH, 5 CORE, 245KV, 50KA/1SEC, 50HZ, 1050KVp BIL, CURRENT TRANSFORMER 2400-1600/1	093–CT, 092–CTA, 092–CTB, 091–CT, 143-CTA, 143-CTB, 083–CT, 082–CTA, 082–CTB, 081–CT 102 for diameter	24 (=8x3)	NOS.
P2 P1	CT	1PH, 2 CORE, 245KV, 50KA/1SEC, 3000A/1A, 50HZ, 1050KVp BIL, CURRENT TRANSFORMER	200–CTA1, 200–CTB1, 200–CTA2, 200–CTB2	12 (=4x3)	NOS.
	CVT	1PH, 3–WINDING, 245KV, 50KA/1SEC, 50HZ, 1050KVp BIL, 4400pF, CAPACITIVE VOLTAGE TRANSFORMER	093–CVT, 091–CVT, 083–CVT, 081–CVT 143-CVT, 200–CVT1, 200–CVT2	3 (=1 x3)	NOS.
	LA	1PH, 196KV RATED VOLTAGE, 160KV(RMS) CONTINUOUS OPERATING VOLTAGE AT 50°C, 10KA, 50HZ, HEAVY DUTY STATION CLASS, METAL OXIDE TYPE, SURGE ARRESTER	093–LA1, 093–LA2, 091–LA, 083–LA1, 083–LA2, 081–LA 103-LA 143-LA,	6 (=2x3)	NOS.

BILL OF QUANTITY – 33kV EQUIPMENTS (31.5kA FOR 1 SEC.)					
SYMBOL	LEGEND	DESCRIPTION	LOCATION	QTY.	UNIT
	52	36KV, 630A, 3PH, 31.5KA/1SEC, 50HZ, 170KVp BIL, SF6 GAS OR VACUUM CIRCUIT BREAKER	301–52, 302–52	2	SETS
	89	36KV, 630A, 3PH, 31.5KA/1SEC, 50HZ, 170KVp BIL, MECHANICALLY GANGED, MOTOR OPERATED HCB DISCONNECTORS	301–89A, 301–89B, 302–89A, 302–89B	4	SETS
	IVT	1PH, 2–WINDING, 36KV, 31.5KA/1SEC, 50HZ, 170KVp BIL, INDUCTIVE VOLTAGE TRANSFORMER	301–IVT, 302–IVT	6 (=2x3)	NOS.
	LA	30KV RATED VOLTAGE, 10KA NOMINAL DISCHARGE CURRENT, 50HZ, HEAVY DUTY STATION CLASS, 1PH SURGE ARRESTER	301–LA1, 302–LA1 303–LA1 301–LA2, 302–LA2 (SEE NOTE – 10)	(=1 x3) 3	NOS.

SYSTEM DESIGN PARAMETERS	400kV SYSTEM	230kV SYSTEM	33kV SYSTEM	230kV OLD S/S
RATED MAXIMUM VOLTAGE	420kV	245kV	36kV	245kV
RATED FREQUENCY	50Hz	50Hz	50Hz	50Hz
RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE	1550kVp (FOR BUS PI) 1425kVp (FOR OTHER EQPT.)	1050kVp	170kVp	1050kVp
RATED SWITCHING IMPULSE WITHSTAND VOLTAGE	1175kVp (FOR BUS PI) 1050kVp (FOR OTHER EQPT.)	–	–	–
POWER FREQUENCY WITHSTAND VOLTAGE	520KV	460KV	70KV	460KV
RATED NOMINAL CURRENT – MAIN BUS	5000A	3000A	–	3000A
RATED SHORT TIME WITHSTAND CURRENT (1 SEC)	50kA	50kA	31.5kA	50kA
RATED SHORT CIRCUIT BREAKING CURENT	50kA	50kA	31.5kA	50kA
RATED SUPPLY CONTROL VOLTAGE	110V DC	110V DC	110V DC	220V DC
HEATER VOLTAGE	412/240V AC	412/240V AC	412/240V AC	412/240V AC

420kV CT DATA (AIS)									
		LINE & TRAFO. BAYS				TIE BAYS			
CORE	RATIO (A/A)	CLASS	RATED OUTPUT	REMARKS	BAY NO.	CLASS	RATED OUTPUT	REMARKS	BAY NO.
1	4000/1A	5P20	60 VA	Rct<=10Ω	401–CT, 403–CT*,	5P20	60 VA	Rct<=10Ω	402–CTA*, 402–CTB*,
2	4000/1A	5P20	60 VA	Rct<=10Ω	404–CT, 406–CT*, 407–CT*,	5P20	60 VA	Rct<=10Ω	405–CTA, 405–CTB, 408–CTA,
3	4000/1A	0.2S	15 VA	ISF<5	409–CT, 410–CT,	0.2S	15 VA	ISF<5	408–CTB, 411–CTA,
4	4000/1A	5P20	60 VA	Rct<=10Ω	412–CT, 413–CT, 415–CT*	5P20	60 VA	Rct<=10Ω	411–CTB, 414–CTA, 414–CTB,
5	4000/1A	PX	–	Vk>=600V, Imag<=60mA, Rct<=10Ω	416–CT	PX	–	Vk>=600V, Imag<=60mA, Rct<=10Ω	417–CTA,
6	4000/1A	PX	–		418 –CT,	PX	–		417–CTB

420kV CVT DATA (AIS)					
WINDINGS	RATIO (KV/KV)	CLASS	BURDEN	PURPOSE	BAY NOS.
1	$\frac{400}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	3P	20 VA	PROTECTION	401–CVT, 403–CVT*, 404–CVT, 406–CVT*, 407–CVT*, 409–CVT, 410–CVT, 412–CVT, 413–CVT, 415–CVT*, 400–CVT1, 400–CVT2 418-CVT
2	$\frac{400}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	3P	20 VA	PROTECTION	
3	$\frac{400}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	0.2	20 VA	METERING	

245kV CT DATA (AIS)					
		LINE & TRAFO. BAYS			
CORE	RATIO (A/A)	CLASS	RATED OUTPUT	REMARKS	BAY NO.
1	2400A/1A	5P20	30 VA	Rct<=10Ω	093–CT, 091–CT, 083–CT, 081–CT 143-CTA,143-CTB, 102 for diameter
2	2400A/1A	5P20	30 VA	Rct<=10Ω	
3	2400A/1A	5P20	30 VA	Rct<=10Ω	
4	2400A/1A	0.2S	15 VA	ISF<5	
5	2400A/1A	PX	–	Vk>=600V, Imag<=60mA, Rct<=10Ω	

		TIE BAYS			
		CLASS	RATED OUTPUT	REMARKS	BAY NO.
		5P20	60 VA	Rct<=10Ω	092–CTA, 092–CTB, 082–CTA, 082–CTB
		5P20	60 VA	Rct<=10Ω	
		0.2	10 VA	ISF<5	
		5P20	60 VA	Rct<=10Ω	
		PX	–	Vk>=600V, Imag<=60mA, Rct<=10Ω	

245kV CVT DATA (AIS)					
WINDINGS	RATIO (kV/kV)	CLASS	BURDEN	PURPOSE	BAY NOS.
1	$\frac{230}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	0.2	25 VA	METERING	143-CVT, 093–CVT, 091–CVT, 083–CVT, 081–CVT, 200–CVT1, 200–CVT2
2	$\frac{230}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	3P	75 VA	PROTECTION	

245kV CT DATA (AIS) (SEE NOTE – 2)					
		BUS SECTIONALIZER BAYS			
CORE	RATIO (A/A)	CLASS	RATED OUTPUT	REMARKS	BAY NO.
1	3000/1A	0.2	10 VA	Rct<=10Ω	200–CTA1, 200–CTA2, 200–CTB1, 200–CTB2
2	3000/1A	PX	–	Vk>=600V, Imag<=60mA, Rct<=10Ω	

36kV IVT DATA (AIS)					
WINDINGS	RATIO (KV/KV)	CLASS	BURDEN	PURPOSE	BAY NOS.
1	$\frac{33}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	3P	15 VA	PROTECTION	301–IVT, 302–IVT
2	$\frac{33}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	0.2	15 VA	METERING	

Scope of work

NOTES:

1. FOR NOTES, REFERENCES AND LEGEND, KINDLY REFER SHEET 1 OF 2 OF THIS DRAWING.

Employer's Approval Stamp

Rev.	Rev. Date	Modification	Drawn By	Created By	Approved By

Drawing/Document Number		LOCATION	MEGHNAGHAT
Customer	POWER GRID COMPANY OF BANGLADESH LTD.,	SUB STATION TYPE	AIS SUBSTATION
Consultant		VOLTAGE LEVEL	400/230kV
Project		Suitability Purpose of	PRELIMINARY ENGINEERING APPROVAL ✓ CONSTRUCTION

Scale	Paper Size	Sign.	Date	LDI No.:
NTS	A0			TBA

Responsible Dept.	Drawn By	Sign.	Date	Document Type	Document Designation
	S.Rahnur		2024.01.17	SINGLE LINE DIAGRAM	
	Created By		2019.07.25	Title	Document Tree
	Approved By		2019.07.25	SINGLE LINE DIAGRAM FOR 400/230kV SWITCHYARD, MEGHNAGHAT	

Rev.	Date of Issue	Language	Sheet
F		EN	2 of 2

21 | 22 | 23 | 24

400kV YARD

220kV YARD

Scope of work

KEY PLAN

UNIQUE PP

AMINBAZAR-I

AMINBAZAR-II

FUTURE

FUTURE

FUTURE

(REFER NOTE -17)

HOLD (REFER NOTE - 5)

DETAIL

400kV MAIN BUS-I

400kV MAIN BUS-II

FENCE

BOUNDARY WALL

BOUNDARY WALL

EXISTING ROAD

Existing Pole Line

GTM. MLV

Existing Valve Chamber-5

Terminal Point - 3

EXISTING FACILITY (SEE NOTE 14)

BOUNDARY WALL

(REFER NOTE -16)

CAR PARKING

PUMP HOUSE

REFER DETAIL-B SHEET 3 OF 3

FENCE

CABLE TRENCH

33kV CABLE

ROAD CULVERT

4 M WIDE ROAD

6 M WIDE ROAD

9.0 M WIDE ROAD

4.0 M WIDE ROAD

3.0M WIDE ROAD

SUMMIT PP

(REFER NOTE -17)

AUTO TRANSFORMER BAY-I

AUTO TRANSFORMER BAY-II

2QT6

2 CIRCUIT TOWER

PT-1

PT-2

EQP

2QT6-1

4 CIRCUIT TOWER

TRANSFORMER

FUTURE TRANSFORMER

FUTURE

FUTURE

400kV SIDE

230kV SIDE

SEE NOTE - 14

℄ OF ROAD

℄ OF 230kV IA

℄ OF 230kV BVI

℄ OF 230kV BS 1E/S

℄ OF 230kV TOWER

℄ OF 230kV BM/EB/CVT

℄ OF 230kV BM/ES/CVT

℄ OF 230kV BM/ES/CVT

℄ OF 230kV BS

℄ OF 230kV CB

℄ OF ROAD

℄ OF 230kV HOT

℄ OF 230kV BS

℄ OF 230kV TOWER

℄ OF 230kV BS

℄ OF 230kV HOT

℄ OF ROAD

℄ OF 230kV CB

℄ OF 230kV CT

℄ OF 230kV BS

℄ OF 230kV TOWER

℄ OF 230kV BS

℄ OF 230kV HOT

℄ OF ROAD

℄ OF 230kV CB

℄ OF 230kV BS

℄ OF 230kV BM/ES/CVT

℄ OF 230kV BM/ES/CVT

℄ OF 230kV BM/ES/CVT

℄ OF 230kV TWR.

℄ OF 230kV BS

℄ OF 230kV CVT

℄ OF 230kV IA

℄ OF ROAD

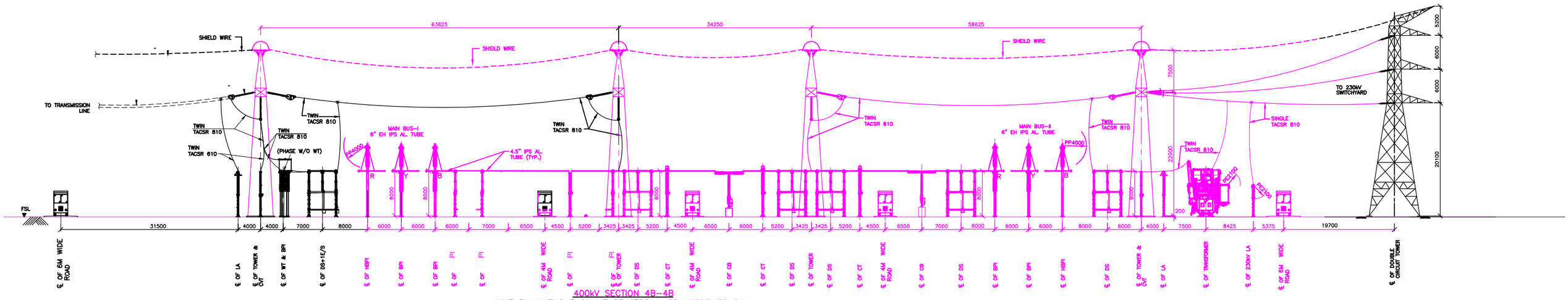
℄ OF 230kV BVI

℄ OF 230kV BS 1E/S

LINE BAY - FUTURE

LINE BAY - FUTURE

Scope of work



400kV SECTION 4B-4B
LINE BAY WITHOUT SHUNT REACTOR & TRANSFORMER BAY

GENERAL NOTES:-

1) ALL DIMENSIONS ARE IN MM. UNLESS OTHERWISE SPECIFIED.
2) SUB-CONDUCTOR DETAILS:-
   TWIN TACSR 610 CONDUCTOR SPACING 450MM
3) INTER-EQUIPMENT DIMENSIONS ARE KEPT TO ACHIEVE NECESSARY PHYSICAL & ELECTRICAL CLEARANCES. IF THE SAME IS NOT ACHIEVED AT SITE, NECESSARY MODIFICATION SHALL BE CARRIED OUT.
4) GAS PIPE LINES ARE SHOWN AS PER GTCL DRAWING.

FSL ▼

LEGENDS:

FENCE
FUTURE
UNDER PRESENT SCOPE
CENTRE LINE
BOUNDARY WALL

SYSTEM DESIGN PARAMETERS	400kV SYSTEM	230kV SYSTEM	33kV SYSTEM	230kV old switchyard
RATED MAXIMUM VOLTAGE	420kV	245kV	36kV	245kV
RATED FREQUENCY	50Hz	50Hz	50Hz	50Hz
RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE	1550kVp (FOR BUS PI) 1425kVp (FOR OTHER EQPT.)	1050kVp	170kVp	1050kVp
RATED SWITCHING IMPULSE WITHSTAND VOLTAGE	1175kVp (FOR BUS PI) 1050kVp (FOR OTHER EQPT.)	-	-	-
POWER FREQUENCY WITHSTAND VOLTAGE	630KV	460KV	70KV	460KV
RATED NOMINAL CURRENT - MAIN BUS	5000A	3000A	-	3000A
RATED SHORT TIME WITHSTAND CURRENT (1 SEC)	50kA	50kA	31.5kA	50kA
RATED SHORT CIRCUIT BREAKING CURENT	50kA	50kA	31.5kA	50kA
RATED SUPPLY CONTROL VOLTAGE	110V DC	110V DC	110V DC	220V DC
HEATER VOLTAGE	415/240V AC	415/240V AC	415/240V AC	415/240V AC

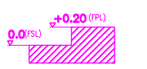
MINIMUM CLEARANCES BETWEEN			
RATED VOLTAGE	400kV	230kV	33kV
BETWEEN PH-E	3500MM	2100MM	380MM
BETWEEN PH-PH	4000MM	2400MM	430MM
GROUND CLEARANCE	2500MM	2500MM	2500MM
SAFETY CLEARANCE	6400MM	4600MM	2800MM
UNIT INSULATOR CREEPAGE DISTANCE	25MM/KV	25MM/KV	25MM/KV

CONNECTION TYPES:-

RATED VOLTAGE/BUS TYPE	400kV	230kV	33kV
MAIN BUS-I & II	6" IPS AL TUBE	4" IPS AL TUBE	
EQUIPMENT BUS	4.5" IPS AL TUBE	4" IPS AL TUBE	SINGLE TACSR 610
JACK BUS - LINE BAY	TWIN TACSR 810	TWIN TACSR 610	
JACK BUS - TRAFO. BAY	TWIN TACSR 810	SINGLE TACSR 810	
JACK BUS - BUS SECTION		TWIN TACSR 610	
DROPPERS	AS PER SECTIONS	AS PER SECTIONS	
DROPPERS - LA, CVT	AS PER SECTIONS	AS PER SECTIONS	
TRAFO. SIDE STRUNG BUS		SINGLE TACSR 810	
EARTH WIRE	7/3.66MM DIA GS WIRE	7/3.66MM DIA GS WIRE	

ABBREVIATIONS:-

LA - SURGE ARRESTOR
BPI - BUS POST INSULATOR
CB - CIRCUIT BREAKER
DS - DISCONNECTOR
DS+1E/S - DISCONNECTOR WITH ONE EARTH SWITCH
CVT - CAPACITOR VOLTAGE TRANSFORMER
WT - WAVE TRAP
BPI - BUS POST INSULATOR
HBPI - HIGH BUS POST INSULATOR
CT - CURRENT TRANSFORMER
PE -PHASE TO EARTH
PP -PHASE TO PHASE
SE -SECTIONS CLEARANCE



FSL - FINISHED SWITCHYARD LEVEL
FPL - FINISHED PLINTH LEVEL
MENTIONED HEIGHTS ARE MINIMUM ABOVE FSL

ABBREVIATIONS:–

LA – SURGE ARRESTOR
BPI – BUS POST INSULATOR
CB – CIRCUIT BREAKER
DS – DISCONNECTOR
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PE –PHASE TO EARTH
PP –PHASE TO PHASE
SE –SECTIONS CLEARANCE

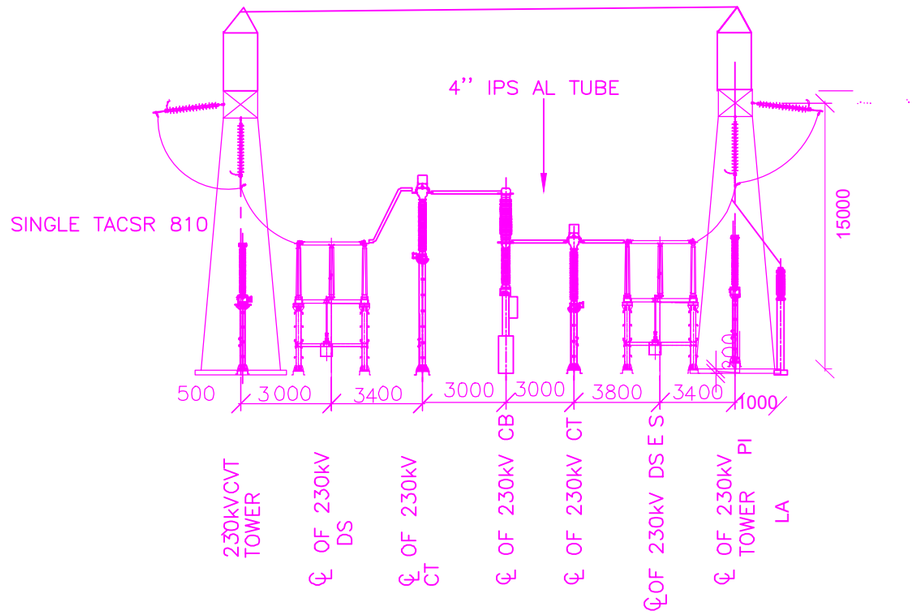
SYSTEM DESIGN PARAMETERS	400kV SYSTEM	230kV SYSTEM	33kV SYSTEM
RATED MAXIMUM VOLTAGE	420kV	245kV	36kV
RATED FREQUENCY	50Hz	50Hz	50Hz
RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE	1550kVp (FOR BUS PI) 1425kVp (FOR OTHER EQPT.)	1050kVp	170kVp
RATED SWITCHING IMPULSE WITHSTAND VOLTAGE	1175kVp (FOR BUS PI) 1050kVp (FOR OTHER EQPT.)	–	–
POWER FREQUENCY WITHSTAND VOLTAGE	630KV	460KV	70KV
RATED NOMINAL CURRENT – MAIN BUS	5000A	3000A	–
RATED SHORT TIME WITHSTAND CURRENT (1 SEC)	50kA	50kA	31.5kA
RATED SHORT CIRCUIT BREAKING CURENT	50kA	50kA	31.5kA
RATED SUPPLY CONTROL VOLTAGE	110V DC	110V DC	110V DC
HEATER VOLTAGE	415/240V AC	415/240V AC	415/240V AC

MINIMUM CLEARANCES BETWEEN			
RATED VOLTAGE	400kV	230kV	33kV
BETWEEN PH–E	3500MM	2100MM	380MM
BETWEEN PH–PH	4000MM	2400MM	430MM
GROUND CLEARANCE	2500MM	2500MM	2500MM
SAFETY CLEARANCE	6400MM	4600MM	2800MM
MIN. INSULATOR CREEPAGE DISTANCE	25MM/KV	25MM/KV	25MM/KV

CONNECTION TYPES:–

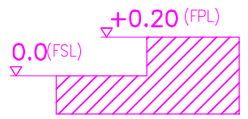
RATED VOLTAGE/BUS TYPE	400kV	230kV	33kV
MAIN BUS–I & II	6" IPS AL TUBE	4" IPS AL TUBE	
EQUIPMENT BUS	4.5" IPS AL TUBE	4" IPS AL TUBE	SINGLE TACSR 610
JACK BUS – LINE BAY	TWIN TACSR 810	TWIN TACSR 610	
JACK BUS – TRAFO. BAY	TWIN TACSR 810	SINGLE TACSR 810	
JACK BUS – BUS SECTION		TWIN TACSR 610	
DROPPERS	AS PER SECTIONS	AS PER SECTIONS	
DROPPERS – LA, CVT	AS PER SECTIONS	AS PER SECTIONS	
TRAFO. SIDE STRUNG BUS		SINGLE TACSR 810	
EARTH WIRE	7/3.66MM DIA GS WIRE	7/3.66MM DIA GS WIRE	

ONE SIDE PEAK FOR OPGW

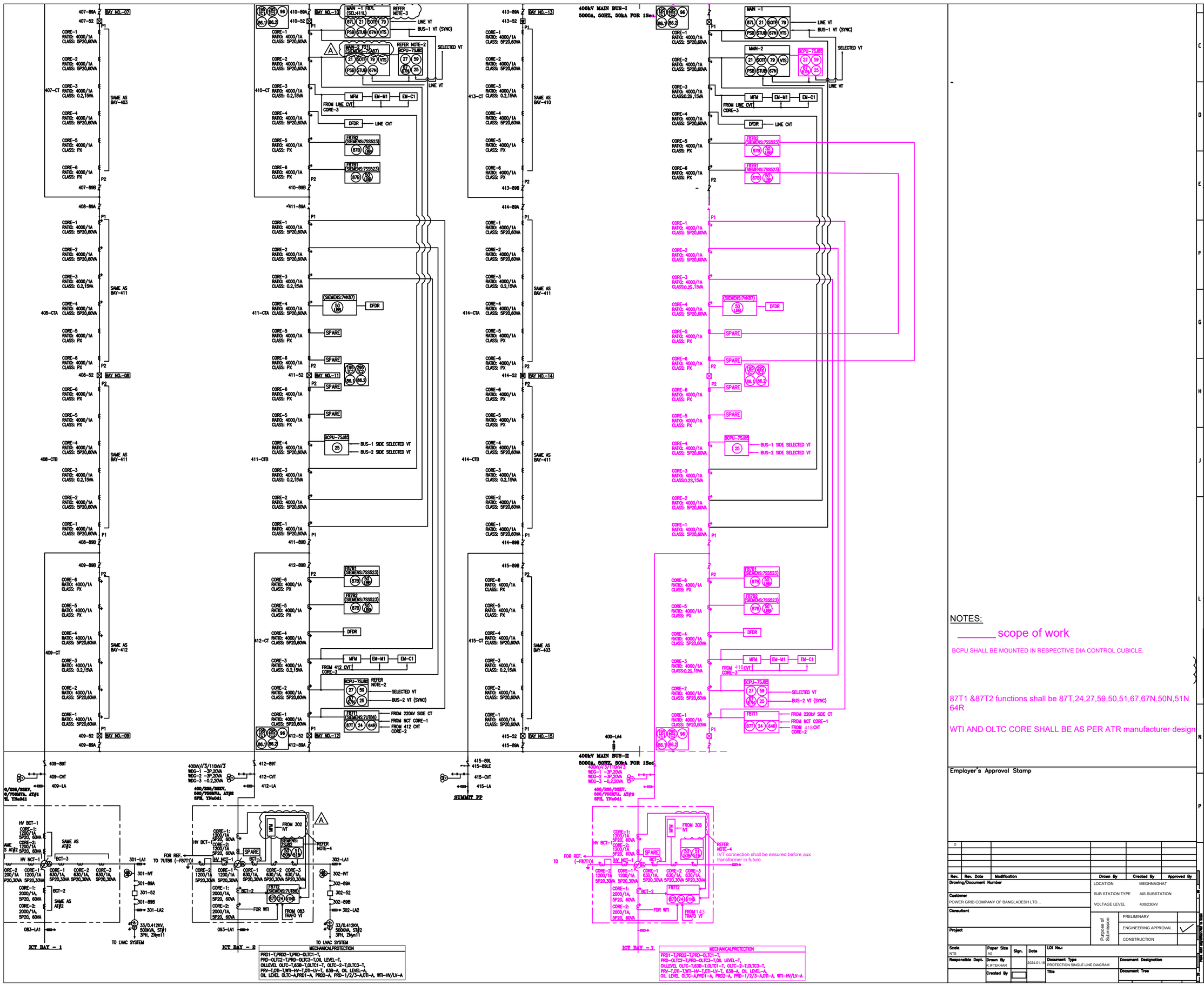


LEGENDS:

FENCE
NOT IN SCOPE/FUTURE
UNDER PRESENT SCOPE
CENTRE LINE
BOUNDARY WALL



FSL – FINISHED SWITCHYARD LEVEL
FPL – FINISHED PLINTH LEVEL
MENTIONED HEIGHTS ARE MINIMUM ABOVE FSL


400kV MAIN BUS-I
5000A, 50HZ, 50kA FOR 1Sec
400kV MAIN BUS-II
5000A, 50HZ, 50kA FOR 1Sec
SUMMIT PP
ICT BAY – 1
ICT BAY – 2
ICT BAY – 3
SAME AS BAY-403
SAME AS BAY-411
SAME AS BAY-412
SAME AS BAY-410
SAME AS BAY-453
MECHANICALPROTECTION
PRD1–T,PRD2–T,PRD–OLTC1–T,
PRD–OLTC2–T,PRD–OLTC3–T,OIL LEVEL–T,
OILLEVEL OLTC–T,63B–T,OLTC1–T, OLTC–2–T,OLTC3–T,
PRV–T,OTI–T,WTI–HV–T,OTI–LV–T, 63B–A, OIL LEVEL–A,
OIL LEVEL OLTC–A,PRD1–A, PRD2–A, PRD–1/2/3–A,OTI–A, WTI–HV/LV–A
NOTES:
scope of work
BCPU SHALL BE MOUNTED IN RESPECTIVE DIA CONTROL CUBICLE.
87T1 &87T2 functions shall be 87T,24,27,59,50,51,67,67N,50N,51N 64R
WTI AND OLTC CORE SHALL BE AS PER ATR manufacturer design
IVT connection shall be ensured before aux transformer in future
Employer's Approval Stamp
Drawing/Document Number
Customer
POWER GRID COMPANY OF BANGLADESH LTD. .
Consultant
Project
LOCATION MEGHNAGHAT
SUB STATION TYPE AIS SUBSTATION
VOLTAGE LEVEL 400/230kV
Purpose of Submission
PRELIMINARY
ENGINEERING APPROVAL
CONSTRUCTION
Scale NTS
Paper Size A0
Responsible Dept.
Drawn By K.IFTEKHAR
Created By
Date 2024.01.16
LOI No.:
Document Type PROTECTION SINGLE LINE DIAGRAM
Document Designation
Title
Document Tree
Rev. Rev. Date Modification Drawn By Created By Approved By

FROM PLIU-3 (PAS PANEL-2),

FROM PLIU-1 (PAS PANEL-1),

TO 2LIU-1B (2SPR-2),

TO 2LIU-1A (2SPR-2),

Location- 4SPR-2

4LIU-2A 12 PORT(LC) PANEL-413

4LIU-2B 12 PORT(LC) PANEL-413CP2

Location- 4SPR-1

4LIU-4B 12 PORT(LC) PANEL-412

4LIU-5A 12 PORT(LC) PANEL-412CP2

4LIU-5B 12 PORT(LC) PANEL-410

4ES-5A (LAN-A)
16 OPTICAL PORT+2 COPPER PORT
PANEL-412
P01 P02 P03 P04 P05 P06 P07 P08 P11 P12 P13 P14 P15 P16 P09 P10 P18 P17

4ES-5B (LAN-B)
16 OPTICAL PORT+2 COPPER PORT
PANEL-410
P01 P02 P03 P04 P05 P06 P07 P08 P11 P12 P13 P14 P15 P16 P09 P10 P18 P17

F87T1
F87T2
BAY-418
400/230/33KV I/C-3
RELAY PANEL

EM-M1
418
EM-M2
143
400kV METERING
DFDR DIA 6

F87L
F87L
BAY-143
230KV OLD -1
RELAY PANEL

F50LBB
FBCPU-1
FBCPU-2
FBCPU-3
400kV CONTROL & TIE
PANEL (DIA-6)

F50LBB
FBCPU-3
FBCPU-2
FBCPU-1
400kV CONTROL & TIE
PANEL (DIA-6)

AVR3
RTCC-3
ICT-3 BAY-418

AVR-4
RTCC-4
ICT-4 BAY-

EM-C1
EM-C2
400kV METERING

4LIU-5A 12 PORT(LC) PANEL-408CP2

4LIU-5B 12 PORT(LC) PANEL-411CP2

4ES-5A (LAN-A)
8 OPTICAL PORT+2 COPPER PORT
PANEL- 408CP2
P03 P04 P05P06 P07 P08 P09P10P02

4ES-5B (LAN-A)
8 OPTICAL PORT+2 COPPER PORT
PANEL- 411CP2
P03 P04 P02 P01 P10P09 P08P07 P06P05

Location- 4SPR-3

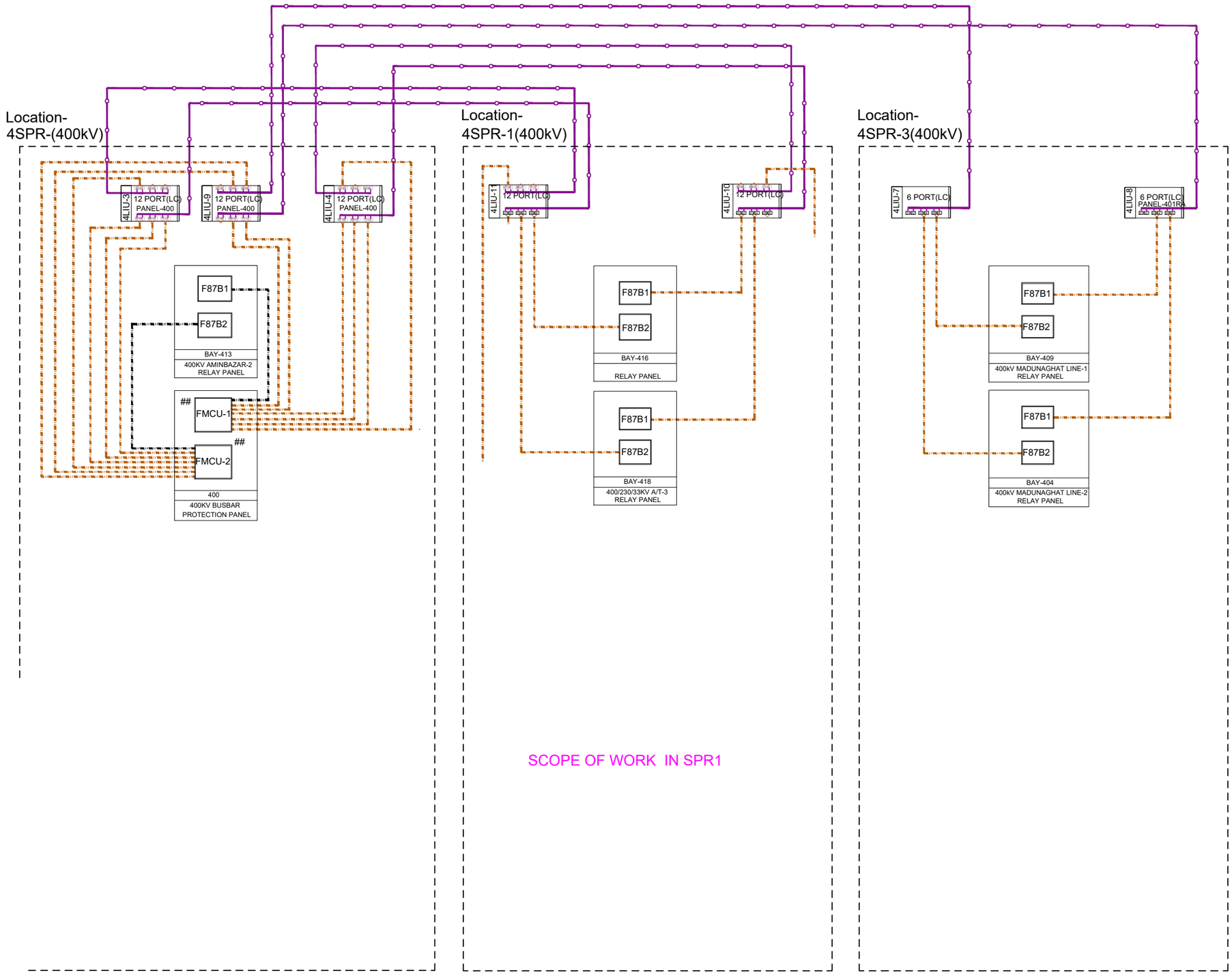
4LIU-3A 12 PORT(LC) PANEL-401B

4LIU-3B 12 PORT(LC) PANEL-402B

Location- 4SPR-1 IS THE SCOPE OF WORK

				Version		400/230kV MEGHNAGHAT		SUBSTATION AUTOMATION SYSTEM	400/230kV MEGHNAGHAT AIS SUBSTATION	C	
				Drawn By	K.I	POWER GRID COMPANY OF BANGLADESH LIMITED					
				Chkd By							
				Appr By		Orig.:	Replaces:	Replaced by:	CONFIGURATION ARCHITECTURE		

BUSBAR ARCHITECTURE FOR 400kV



SCOPE OF WORK IN SPR1

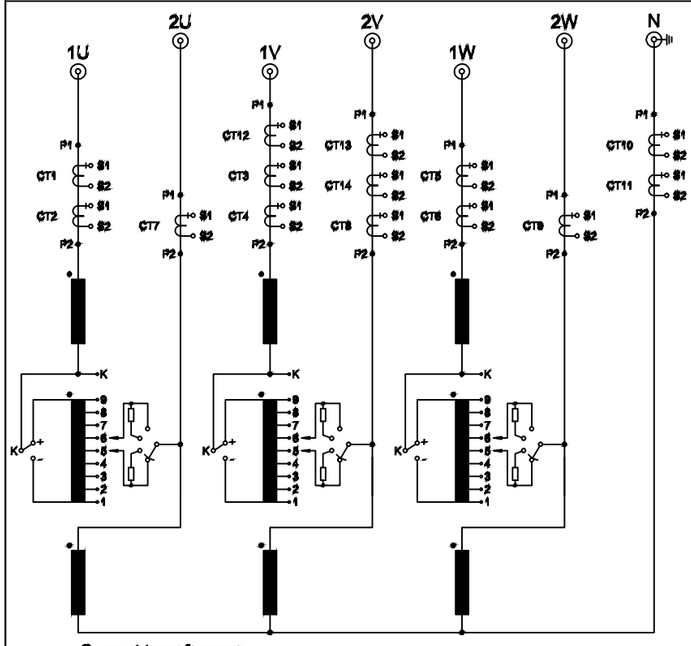
FOR BUSBAR
SUBSTATION AUTOMATION SYSTEM

400/230kV MEGHNAGHAT AIS
SUBSTATION

CONFIGURATION ARCHITECTURE

Three-Phase Autotransformer Type TAQ-505R44F9K-99

Rating	750 / 750 / 150 MVA	Rated voltages	400 ± 8x1.25% / 235 / 33 kV	Year of manufacture	-
Frequency	50 Hz	Type of cooling	ONAN/ONAF	Serial number	-
Connection symbol	YNa0d1	Standard	IEC 60076-1		
Um	420 / 245 / 36 kV	OLTC type	3xVM I 1203-245/C-10193W	Symetric Short Circuit Capacity	HV: 50kA, 1sec LV: 50kA, 1sec TV: 31.5kA, 1sec



High Voltage

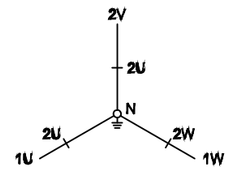
OLTC tap position	Mechanism Connects		Volts	Amps
	Diverter Switch	Selector Switch	Line to Line	at 750 MVA
17	1	K to +	440000	984
16	2		435000	995
15	3		430000	1007
14	4		425000	1019
13	5		420000	1031
12	6		415000	1043
11	7		410000	1056
10	8		405000	1069
9C	9		400000	1083
9B	K	K to -	400000	1083
9A	1		400000	1083
8	2		395000	1096
7	3		390000	1110
6	4		385000	1125
5	5		380000	1140
4	6		375000	1155
3	7		370000	1170
2	8		365000	1186
1	9		360000	1203

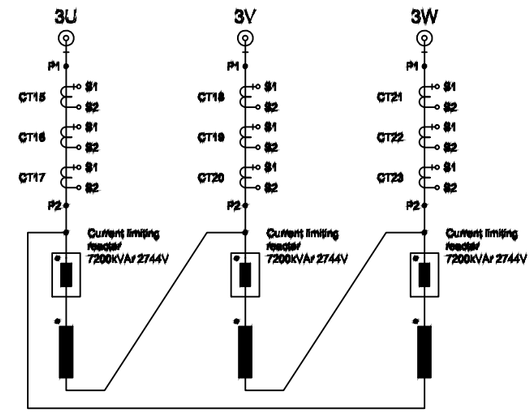
Low Voltage

Volts	Amps
Line to Line	at 750 MVA
235 000	1843

Current transformers

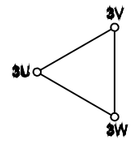
CT No.	Ratio	Burden	Class	Function
CT1 - 6	1200 / 1A	60VA	5P20	Protection CT
CT7, 8, 9	2000 / 1A	60VA	5P20	Protection CT
CT10 - 11	1200 / 1A	30VA	5P20	Protection CT
CT12	1203 / 1A	15VA	3	WTI
CT13	2406 / 1A	10VA	3	MR monitoring
CT14	1843 / 1A	15VA	3	WTI
CT15 - 23	630 / 1A	30VA	5P20	Protection CT





Tertiary Voltage

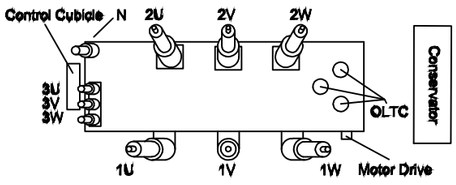
Volts	Amps
Line to Line	at 150 MVA
33 000	2624



Insulation levels

	LIL (kV)	SIL (kV)	AC (kV)
HV line	1425	1050	630
LV line	1050	-	460
Neutral	-	-	38
TV line	170	-	70

Terminal arrangement



Approximate masses and volumes:

Core and coils (without residual oil)		- kg
Tank with cover and bushing adapters		- kg
Cooling plant (without oil)		- kg
Conservator (without oil)		- kg
Bushings, wiring and accessories		- kg
Oil mass total		- kg
Transformer completely assembled		- kg
Shipping mass (dry air-filled)		- kg
Untanking mass		- kg
Oil (volumes at 25°C):		
Oil in tank	-1/	- kg
Oil in cooling plant	-1/	- kg
Oil in conservator main compartment	-1/	- kg
Oil in conservator OLTC compartment	-1/	- kg
Oil mass total	-1/	- kg

Temperature rise:

55K top oil temperature rise at 750MVA
60K average winding temperature rise at 750MVA
73K winding hot spot temperature rise at 750MVA

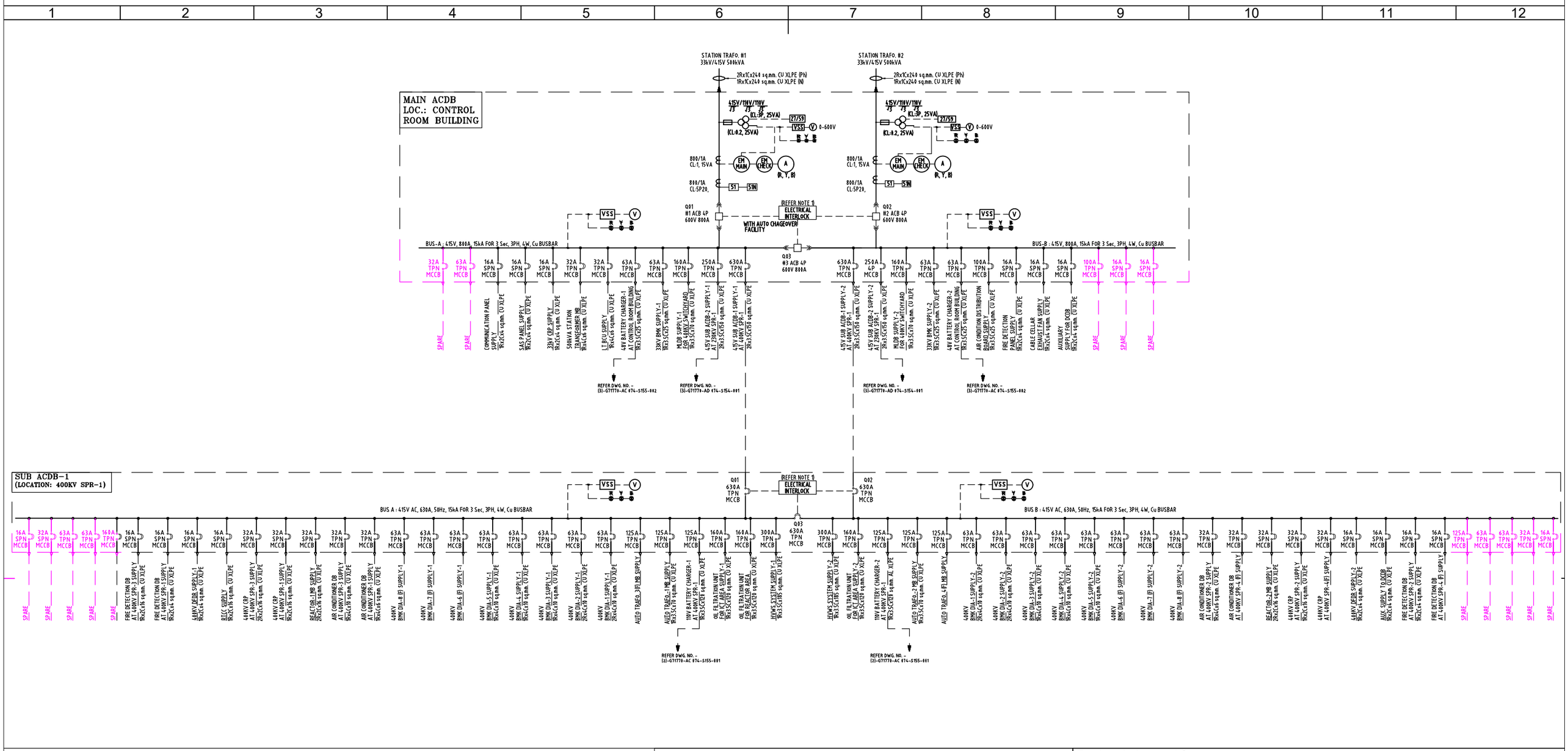
Impedance:

- % HV/LV at 750MVA, tap position 9B (400/235 kV)
- % HV/TV at 150MVA, tap position 9B (400/33 kV)
- % LV/TV at 150MVA, (235/33 kV)

Tank, conservator and radiators are designed for full vacuum.

Work Order	
Serial Number	- - - -
Year of manufacture	- -
Impedance in % HV/LV at 750 MVA (Tap 9B)	- -
Impedance in % HV/TV at 150 MVA (Tap 9B)	- -
Impedance in % LV/TV at 150 MVA	- -
QR-Code	

Finish: Drawing and letters black, recessed
Background: Polished
Material: Stainless steel; 2mm thick



NOTES:

1) ELECTRICAL INTERLOCK B/W Q01,Q02,Q03 SHALL BE PROVIDED SUCH THAT UNDER NORMAL CONDITIONS, Q01 & Q02 SHALL BE IN CLOSED CONDITION, WHEREAS Q03 SHALL BE OPEN. HOWEVER, IN CASE OF FAILURE OF MAIN SUPPLY FROM ANY OF THE INCOMER, RESPECTIVE BREAKER WILL TRIP AND BUS COUPLER SHALL BE CLOSED.
2) A MCB/MCCB TRIP SIGNAL STATUS FOR THE GROUP CONTAINING ALL THE MCB/MCCB UNDER EACH LVAC/LVDC INCOMER SHALL HAVE TO BE KEPT IN THE SAS SYSTEM.
3) THE SEQUENCE OF FEEDERS IS INDICATIVE ONLY AND CAN BE REARRANGED (WITHOUT CHANGING THE BUS SECTION) TO ACHIEVE OPTIMIZED PHYSICAL SIZE.
4) ALL THE MCCBs ARE FLUSH MOUNTED & ACBs ARE DRAWOUT TYPE.

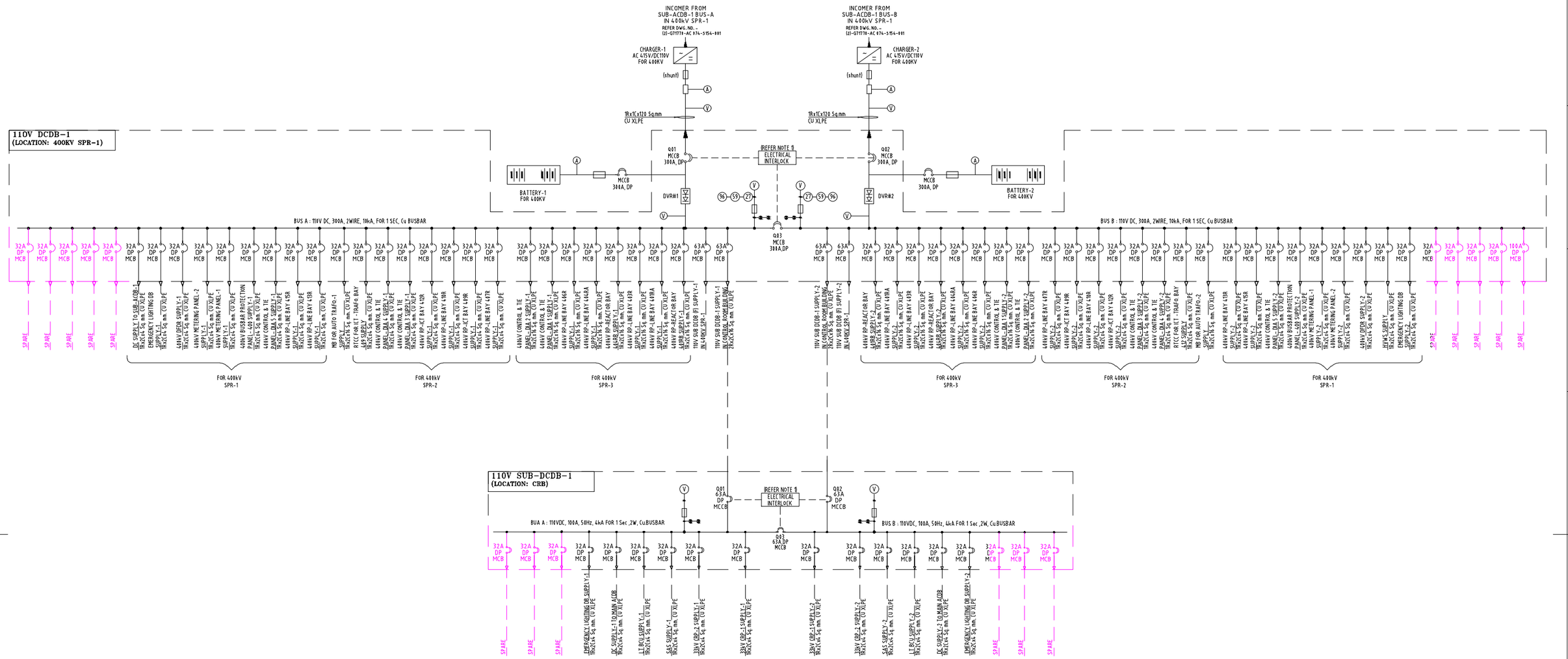
LEGENDS:

- ACB — AIR CIRCUIT BREAKER (DRAW-OUT TYPE)
- MCCB — MOLDED CASE CIRCUIT BREAKER
- MCB — MINIATURE CIRCUIT BREAKER
- INDICATING LAMP
- (V) VOLTMETER
- (A) AMMETER
- 27 UNDER VOLTAGE
- 59 OVER VOLTAGE

Employer's Approval Stamp

Rev.	Date	Modification	Drawn By	Created By	Approved By
D					

Drawing/Document Number — LOCATION — MECHANICHAT



NOTES:

1) ELECTRICAL INTERLOCK B/W Q.01,Q.02,Q.03 SHALL BE PROVIDED SUCH THAT UNDER NORMAL CONDITIONS, Q.01 & Q.02 SHALL BE IN CLOSED CONDITION, WHEREAS Q.03 SHALL BE OPEN. HOWEVER, IN CASE OF FAILURE OF MAIN SUPPLY FROM ANY OF THE INCOMER, RESPECTIVE BREAKER WILL TRIP AND BUS COUPLER SHALL BE CLOSED.
2) A MCB/MCCB TRIP SIGNAL STATUS FOR THE GROUP CONTAINING ALL THE MCB/MCCB UNDER EACH LVAC/LVDC INCOMER SHALL HAVE TO BE KEPT IN THE SAS SYSTEM.
3) THE SEQUENCE OF FEEDERS IS INDICATIVE ONLY AND CAN BE REARRANGED (WITHOUT CHANGING THE BUS SECTION) TO ACHIEVE OPTIMIZED PHYSICAL SIZE.
4) ALL THE MCCBs ARE FLUSH MOUNTED & ACBs ARE DRAWOUT TYPE.
5) THIS DRAWING SHALL BE READ IN CONJUCTION WITH THE SPECIFICATIONS.
6) ADEQUATE NUMBER OF TERMINALS TO BE PROVIDED FOR SPECIFIED RUNS & SIZE OF CABLE.

LEGENDS:

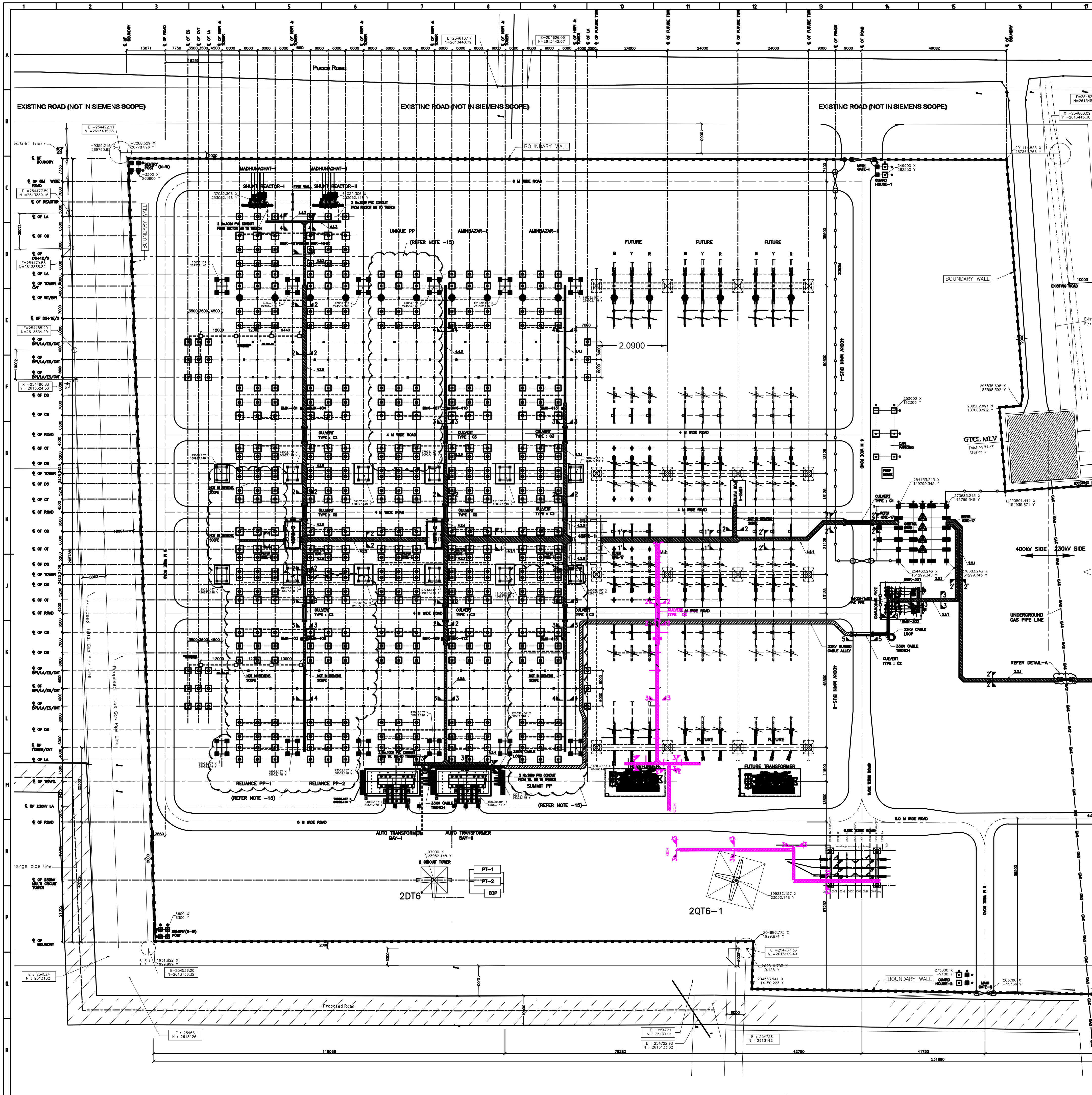
- MCCB — MOLDED CASE CIRCUIT BREAKER
- MCB — MINIATURE CIRCUIT BREAKER
- FUSE
- INDICATING LAMP
- (V) VOLTMETER
- (A) AMMETER
- 27 UNDER VOLTAGE
- 59 OVER VOLTAGE
- 96 BATTERY EARTH FAULT

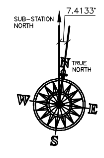
ABBREVIATIONS:

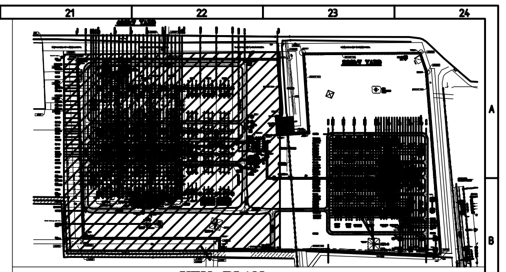
DP = DOUBLE POLE NEUTRAL
RP = RELAY PANEL
CRP = CONTROL RELAY PANEL
MB = MARSHALLING BOX
BCU = BAY CONTROL UNIT
ACDB = AC DISTRIBUTION BOARD
DCDB = DC DISTRIBUTION BOARD
SPR = SWITCHYARD PANEL ROOM
HVWS = HIGH VELOCITY WATER SPRAY
RTCC = REMOTE TAPCHANGER CONTROL CUBICLE
DFDR = DIGITAL FAULT DETECTOR & RECORDER

Employer's Approval Stamp

Document Type	SINGLE LINE DIAGRAM
Document Designation	
Title	LT AUXILIARY 110V DC SYSTEM FOR 400KV SWITCHYARD MEGHNAGHAT
Rev.	
Date of Issue	
Language	EN
Sheet	1 of 1







KEY PLAN

LEGENDS:

- UNDER PRESENT SCOPE
- FUTURE/NOT IN SCOPE
- CABLE TRENCH
- ROAD CROSSING
- BAY MARSHALLING KIOSK (BMK)
- PVC PIPES
- 33KV BURIED CABLE ALLEY (FOR 2NOS. CIRCUIT)
- 33KV BURIED CABLE ALLEY (FOR 1NO. CIRCUIT)

REFERENCE DRAWINGS:

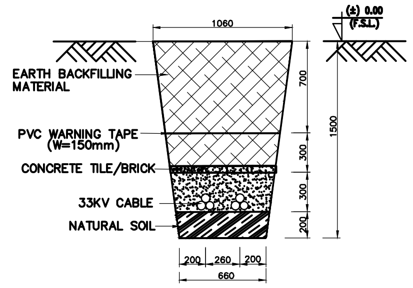
1. LAYOUT PLAN & SECTION FOR MEGHNAGHAT 400/230kV AIS S/S

ABBREVIATIONS:-

- LA - SURGE ARRESTOR
- BPI - BUS POST INSULATOR
- CB - CIRCUIT BREAKER
- DS - DISCONNECTOR
- DS+1E/S - DISCONNECTOR WITH ONE EARTH SWITCH
- CVT - CAPACITOR VOLTAGE TRANSFORMER
- WT - WAVE TRAP
- BPI - BUS POST INSULATOR
- HBPI - HIGH BUS POST INSULATOR
- CT - CURRENT TRANSFORMER
- MB - MARSHALLING BOX
- JB - JUNCTION BOX

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. EARTH FLAT IN CABLE TRENCH (25MM X 6MM CU FLAT) WILL RUN ALONG THE TOP TIER OF EACH CABLE TRENCH SECTION. PROVISION WILL BE KEPT TO CONNECT EXTERNAL EARTH GRID AT EVERY 30MTR. INTERVAL.
3. PVC PIPES WILL BE PROVIDED TO TAKE CABLES OUT FROM TRENCH TO RESPECTIVE EQUIPMENT. DEPTH OF BURIAL SHALL BE 250MM BELOW FINISHED SWITCHYARD LEVEL. TYPICAL ARRANGEMENT HAS BEEN INDICATED IN THIS DRAWING.
4. DETAILS AT ROAD CROSSING SHALL BE PROVIDED IN CIVIL DRAWING.
5. AFTER LAYING THE CABLES THE ENDS OF PVC PIPE SHALL BE SUITABLY SEALED AT SITE TO PREVENT INGRESS OF WATER INSIDE THE PVC PIPE.
6. SEPARATE PVC PIPES SHALL BE PROVIDED FOR POWER AND CONTROL CABLES.
7. POWER AND CONTROL CABLES IN CABLE TRENCHES SHALL BE LAID IN SEPARATE TIER. CABLE TRENCH ROUTE IS INDICATIVE ONLY. IT MAY BE CHANGED DURING CONSTRUCTION TO SUIT THE SITE CONDITIONS.
8. SLOPE OF CABLE TRENCH SHALL BE SHOWN IN CIVIL DRAWING.
9. TRENCH WALL SHALL CLEAR THE EQUIPMENT FOUNDATION BY SUITABLE GAP.
10. CABLE TRENCH / PVC PIPE NEAR ISOLATOR WILL BE ROUTED SUCH THAT LOCATION OF AUX. EARTHMAT FALLS UNDER OPERATING MECHANISM BOX.
11. PULL PIT SHALL BE CONSTRUCTED WHEREVER REQUIRED AS PER SITE AVAILABILITY AND FEASIBILITY.



BURIED CABLE ALLEY DETAILS FOR 2 NOS. 33kV CIRCUITS
(SCALE: 1:20)

0.0 (FSL) +0.20 (FPL)

FSL - FINISHED SWITCHYARD LEVEL
FPL - FINISHED PLINTH LEVEL
MENTIONED HEIGHTS ARE MINIMUM ABOVE FSL

Employer's Approval Stamp

Rev.	Rev. Date	Modification	Drawn By	Created By	Approved By
F					

Drawing/Document Number

Customer: POWER GRID COMPANY OF BANGLADESH LTD. ,

Consultant

Project

LOCATION	MEGHNAGHAT
SUB STATION TYPE	AIS SUBSTATION
VOLTAGE LEVEL	400/230kV

Purpose of Submission: PRELIMINARY / ENGINEERING APPROVAL / CONSTRUCTION

Scale	Paper Size	Sign.	Date	LOI No.:
1:450mm	A0			

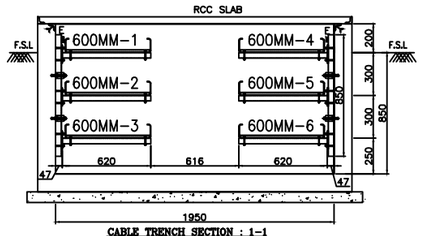
Responsible Dept. | Drawn By: K.I | Created By | Approved By

Document Type | Document Designation | Document Tree

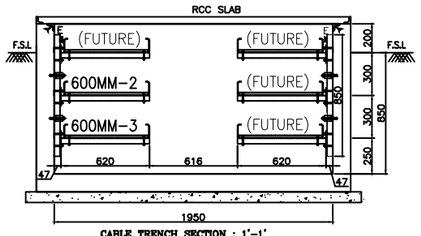
Title: OUTDOOR CABLE ROUTING & TRENCH LAYOUT FOR 400/230kV SWITCHYARD, MEGHNAGHAT

Rev.	Date of Issue	Language	Sheet
F		EN	1 of 3

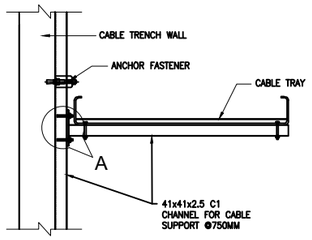
4SPR-1
4.2.3
4.1.1
REFER NOTE-17
4.2.6
4.1.2
4.2.1
NOT IN SIEMENS SCOPE
CONTROL ROOM BUILDING
NOTE-17
2.2.1
254433.243 X 131299.345 Y
270683.243 X 131299.345 Y
3.3.1
BMK-301
BMK-302
33kv SWITCHYARD
1x100ø+1x50ø PVC PIPE
33KV CABLE LOOP
33KV CABLE TRENCH
33KV BURIED CABLE ALLEY
CULVERT TYPE : C2
4 M WIDE ROAD
BMK-415
400kV SIDE
230kV S
UNDERGROUND GAS PIPE LINE
REFER DETAIL-A
GAS
21125
13125
45500
400KV MAIN BUS-II
NOT IN SIEMENS SCOPE
6000
121032.157 X 68052.148 Y
33KV CABLE LOOP
2 No.100ø PVC CONDUIT FROM TR. MB TO TRENCH
SUMMIT PP
120317.157 X 56202.148 Y
(REFER NOTE -15)
145032.157 X 68052.148 Y
FUTURE
FUTURE
TRANSFORMER
FUTURE TRANSFORMER
HDD
11500
13800
9.0M WIDE ROAD
6.0 M WIDE ROAD
230KV CVT& GANTRY
230KV DS
230KV CB GANG
230KV DS
230KV PI & GANTRY
230KV LA
Gantry column one side peak
2000
3400 3800 3000 3000 3000 3400 2000
1000
199282.157 X 23052.148 Y
2QT6-1
57292
59500
6 M WIDE ROAD



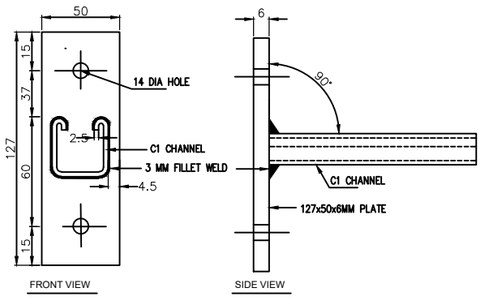
CABLE TRENCH SECTION : 1–1
(SCALE: 1:15)



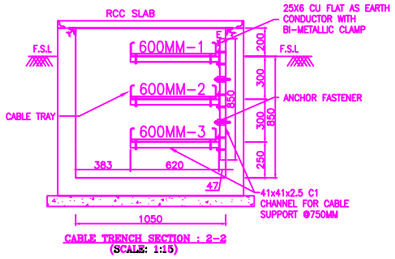
CABLE TRENCH SECTION : 1'–1'
(SCALE: 1:15)



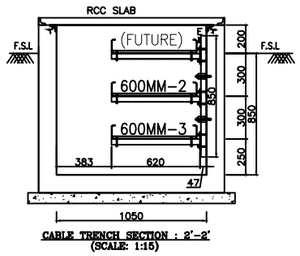
TYPICAL CABLE SUPPORT
SCALE–NTS



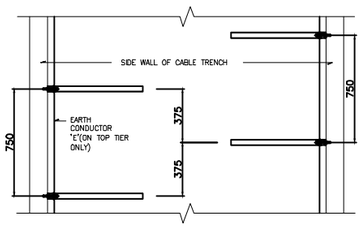
DETAIL-A
SCALE–NTS



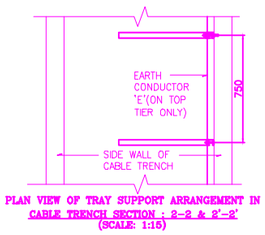
CABLE TRENCH SECTION : 2–2
(SCALE: 1:15)



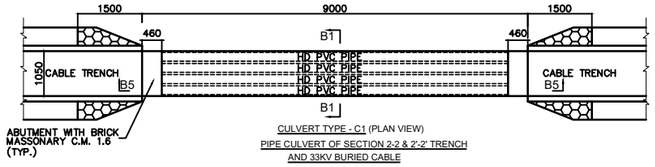
CABLE TRENCH SECTION : 2'–2'
(SCALE: 1:15)



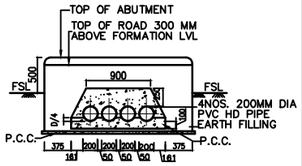
PLAN VIEW OF TRAY SUPPORT ARRANGEMENT IN
CABLE TRENCH SECTION : 1–1
(SCALE: 1:15)



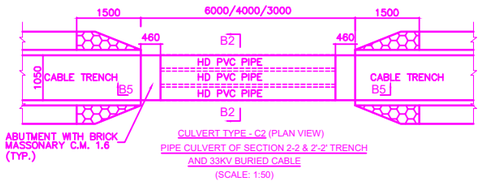
PLAN VIEW OF TRAY SUPPORT ARRANGEMENT IN
CABLE TRENCH SECTION : 2–2 & 2'–2'
(SCALE: 1:15)



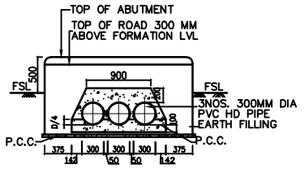
CULVERT TYPE - C1 (PLAN VIEW)
PIPE CULVERT OF SECTION 2-2 & 2'-2' TRENCH
AND 33KV BURIED CABLE
(SCALE: 1:50)



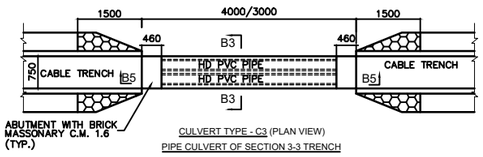
SECTION B1-B1
(SCALE: 1:30)



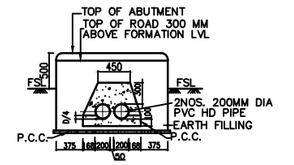
CULVERT TYPE - C2 (PLAN VIEW)
PIPE CULVERT OF SECTION 2-2 & 2'-2' TRENCH
AND 33KV BURIED CABLE
(SCALE: 1:50)



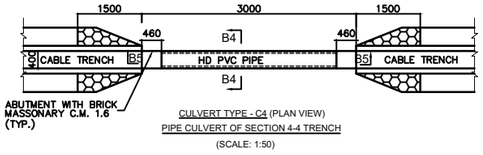
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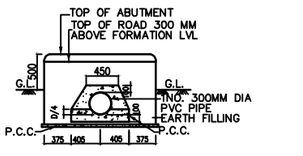
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PIPE CULVERT OF SECTION 3-3 TRENCH
(SCALE: 1:50)



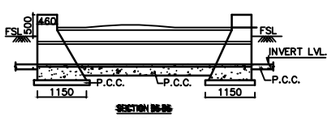
SECTION B3-B3
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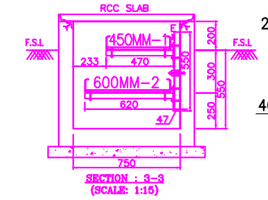
CULVERT TYPE - C4 (PLAN VIEW)
PIPE CULVERT OF SECTION 4-4 TRENCH
(SCALE: 1:50)



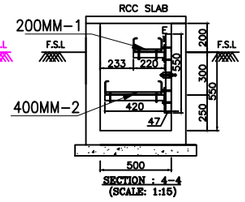
SECTION B4-B4
(SCALE: 1:30)



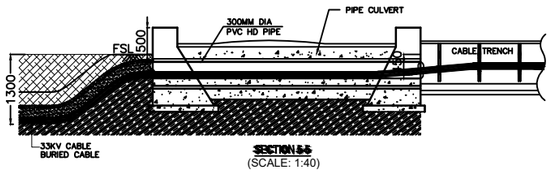
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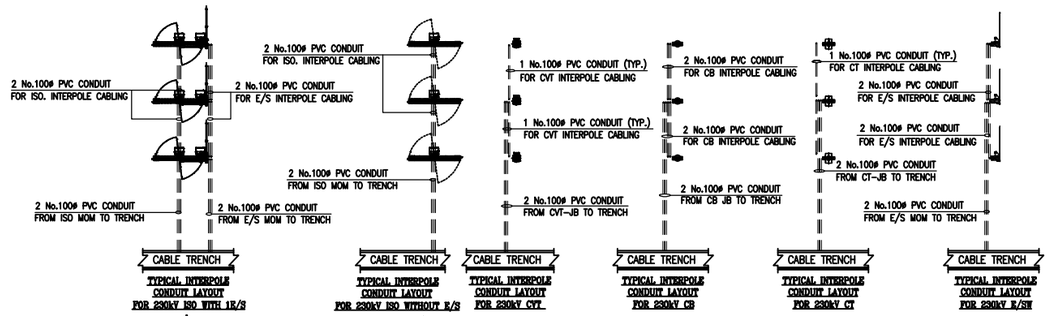
SECTION : 3–3
(SCALE: 1:15)



SECTION : 4–4
(SCALE: 1:15)



SECTION 5-5
(SCALE: 1:40)



TYPICAL INTERPOLE CONDUIT LAYOUT FOR 230kV ISO WITH 1E/S

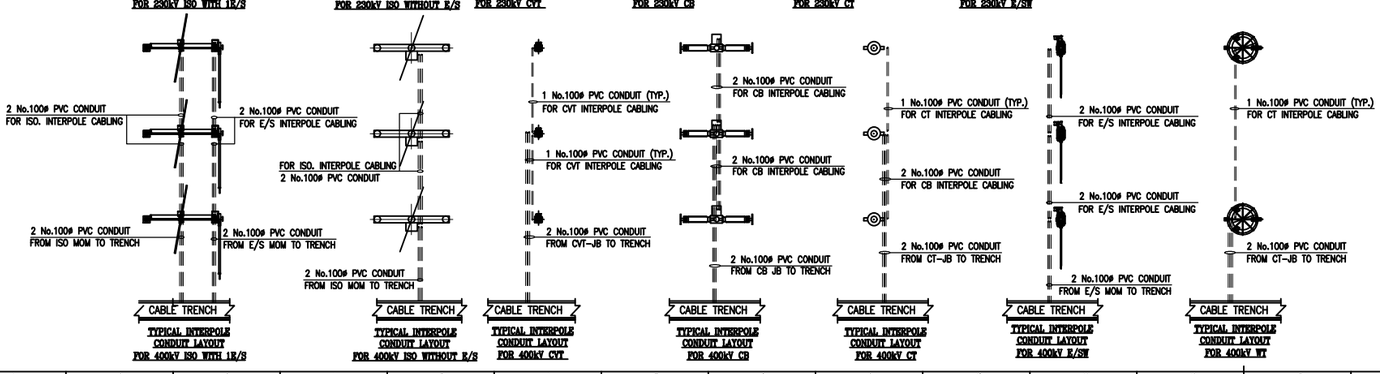
TYPICAL INTERPOLE CONDUIT LAYOUT FOR 230kV ISO WITHOUT E/S

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 230kV CVT

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 230kV CB

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 230kV CT

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 230kV E/SW



TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV ISO WITH 1E/S

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV ISO WITHOUT E/S

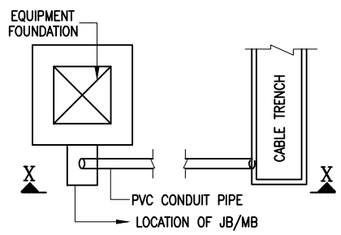
TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV CVT

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV CB

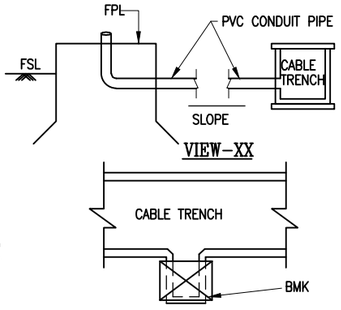
TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV CT

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV E/SW

TYPICAL INTERPOLE CONDUIT LAYOUT FOR 400kV WT



TYP. CABLE EXIT THROUGH CONDUIT
FROM TRENCH



TYPICAL INSTALLATION FOR BMK

LEGENDS:

- UNDER PRESENT SCOPE
- FUTURE/NOT IN SCOPE
- CABLE TRENCH
- RAIL CROSSING
- DRY MARSHALLING KIOSK (DMK)
- PVC PIPES
- 33KV BURIED CABLE ALLEY (FOR 3NOS. CIRCUIT)
- 33KV BURIED CABLE ALLEY (FOR 1NO. CIRCUIT)

REFERENCE DRAWINGS:

1. LAYOUT PLAN & SECTION FOR MEGHNAGHAT 400/230kV AIS S/S

ABBREVIATIONS:–

- LA – SURGE ARRESTOR
- BPI – BUS POST INSULATOR
- CB – CIRCUIT BREAKER
- DS – DISCONNECTOR
- DS+1E/S – DISCONNECTOR WITH ONE EARTH SWITCH
- CVT – CAPACITOR VOLTAGE TRANSFORMER
- WT – WAVE TRAP
- BPI – BUS POST INSULATOR
- HBPI – HIGH BUS POST INSULATOR
- CT – CURRENT TRANSFORMER
- MB – MARSHALLING BOX
- JB – JUNCTION BOX

NOTES:–

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. EARTH FLAT IN CABLE TRENCH (25MM X 6MM CU FLAT) WILL RUN ALONG THE TOP TIER OF EACH CABLE TRENCH SECTION. PROVISION WILL BE KEPT TO CONNECT EXTERNAL EARTH GRID AT EVERY 30MTR. INTERVAL.
3. PVC PIPES WILL BE PROVIDED TO TAKE CABLES OUT FROM TRENCH TO RESPECTIVE EQUIPMENT. DEPTH OF BURIAL SHALL BE 250MM BELOW FINISHED SWITCHYARD LEVEL. TYPICAL ARRANGEMENT HAS BEEN INDICATED IN THIS DRAWING.
4. DETAILS AT ROAD CROSSING SHALL BE PROVIDED IN CIVIL DRAWING.
5. AFTER LAYING THE CABLES THE ENDS OF PVC PIPE SHALL BE SUITABLY SEALED AT SITE TO PREVENT INGRESS OF WATER INSIDE THE PVC PIPE.
6. SEPARATE PVC PIPES SHALL BE PROVIDED FOR POWER AND CONTROL CABLES.

0.0(FSL) +0.30(FPL)

FSL – FINISHED SWITCHYARD LEVEL.
FPL – FINISHED PLINTH LEVEL.
MENTIONED HEIGHTS ARE MINIMUM ABOVE FSL

Employer's Approval Stamp

Rev.	Rev. Date	Modification	Drawn By	Created By	Approved By

Drawing/Document Number

Customer: POWER GRID COMPANY OF BANGLADESH LTD. .

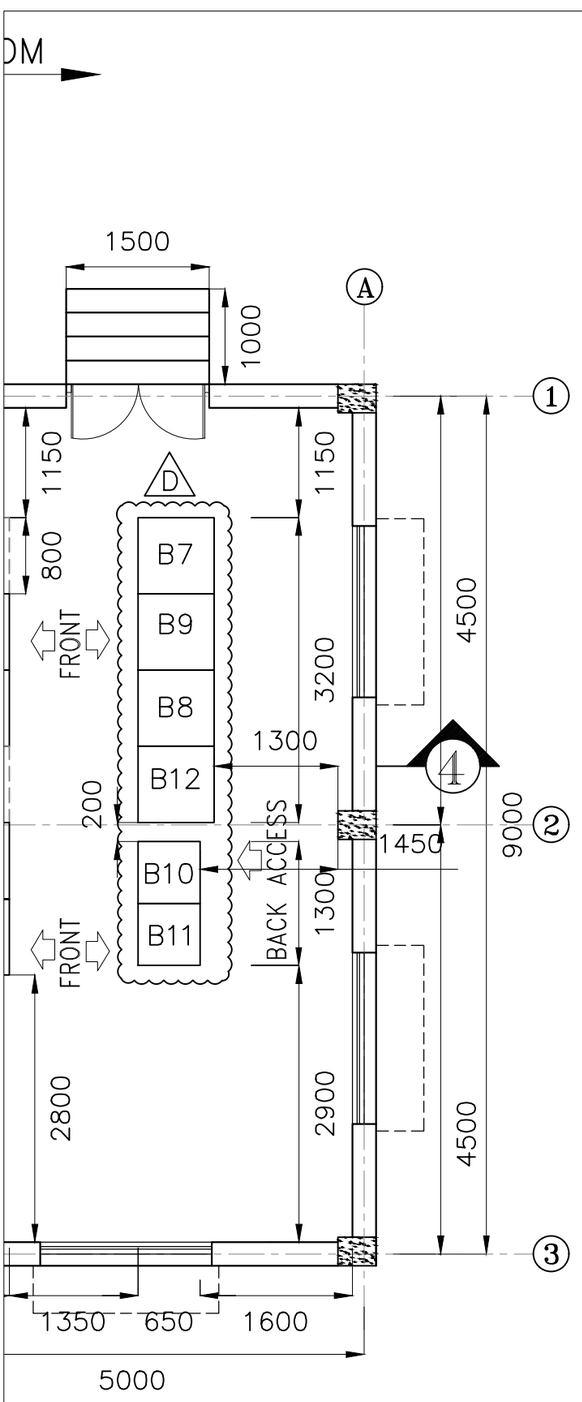
Consultant

Project

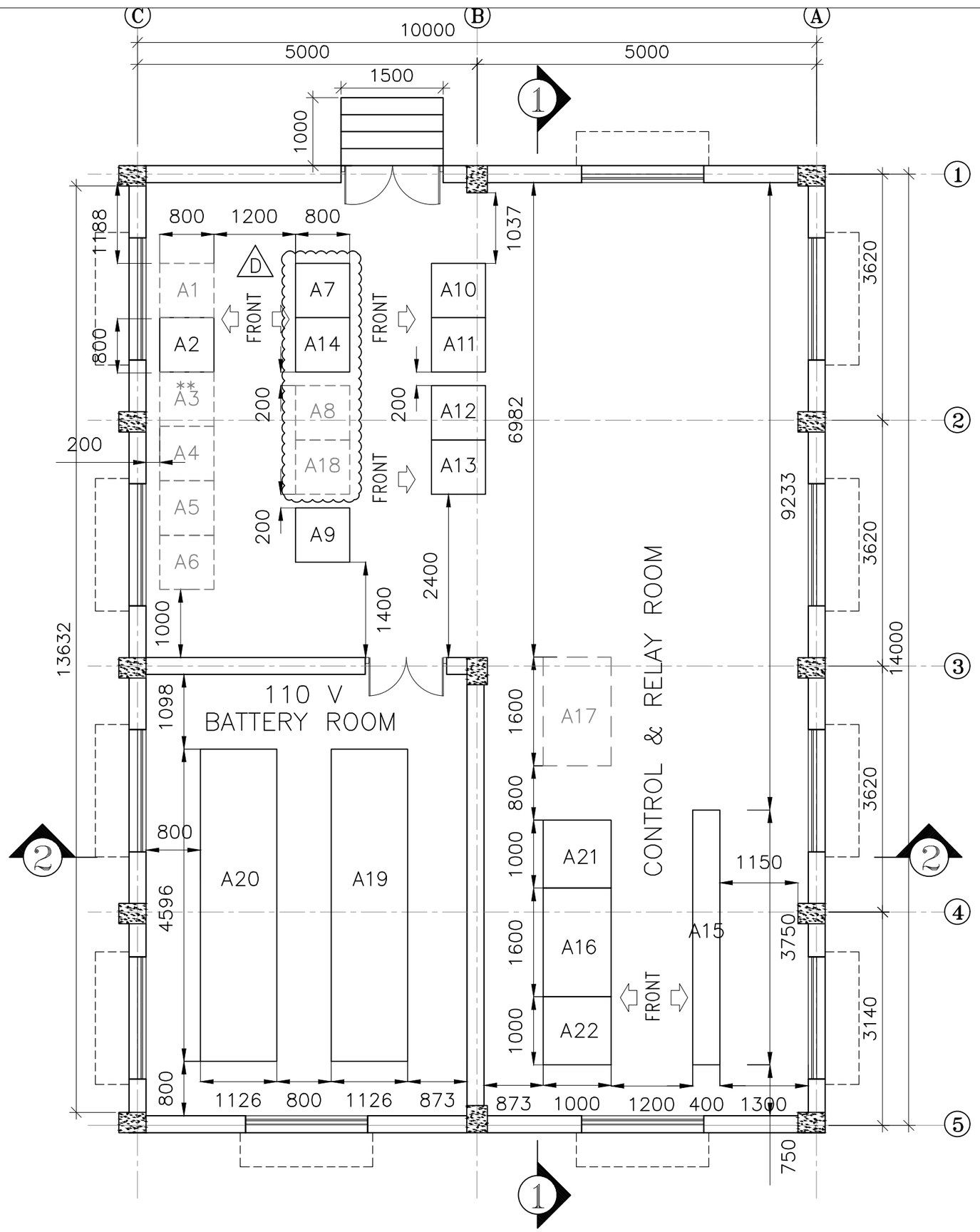
LOCATION: MEGHNAGHAT
SUB STATION TYPE: AIS SUBSTATION
VOLTAGE LEVEL: 400/230kV

Purpose of Submission: PRELIMINARY / ENGINEERING APPROVAL / CONSTRUCTION

Scale	Paper Size	Sign.	Date	LCI No.:
1:400mm	A0			
Responsible Dept.	Drawn By			Document Type / Document Designation
	Created By			Title: OUTDOOR CABLE ROUTING & TRENCH LAYOUT FOR 400/230kV SWITCHYARD, MEGHNAGHAT
	Approved By			Document Tree / Rev. / Date of Issue / Language / Sheet: EN 3 of 3



SPR-2 LAYOUT PLAN



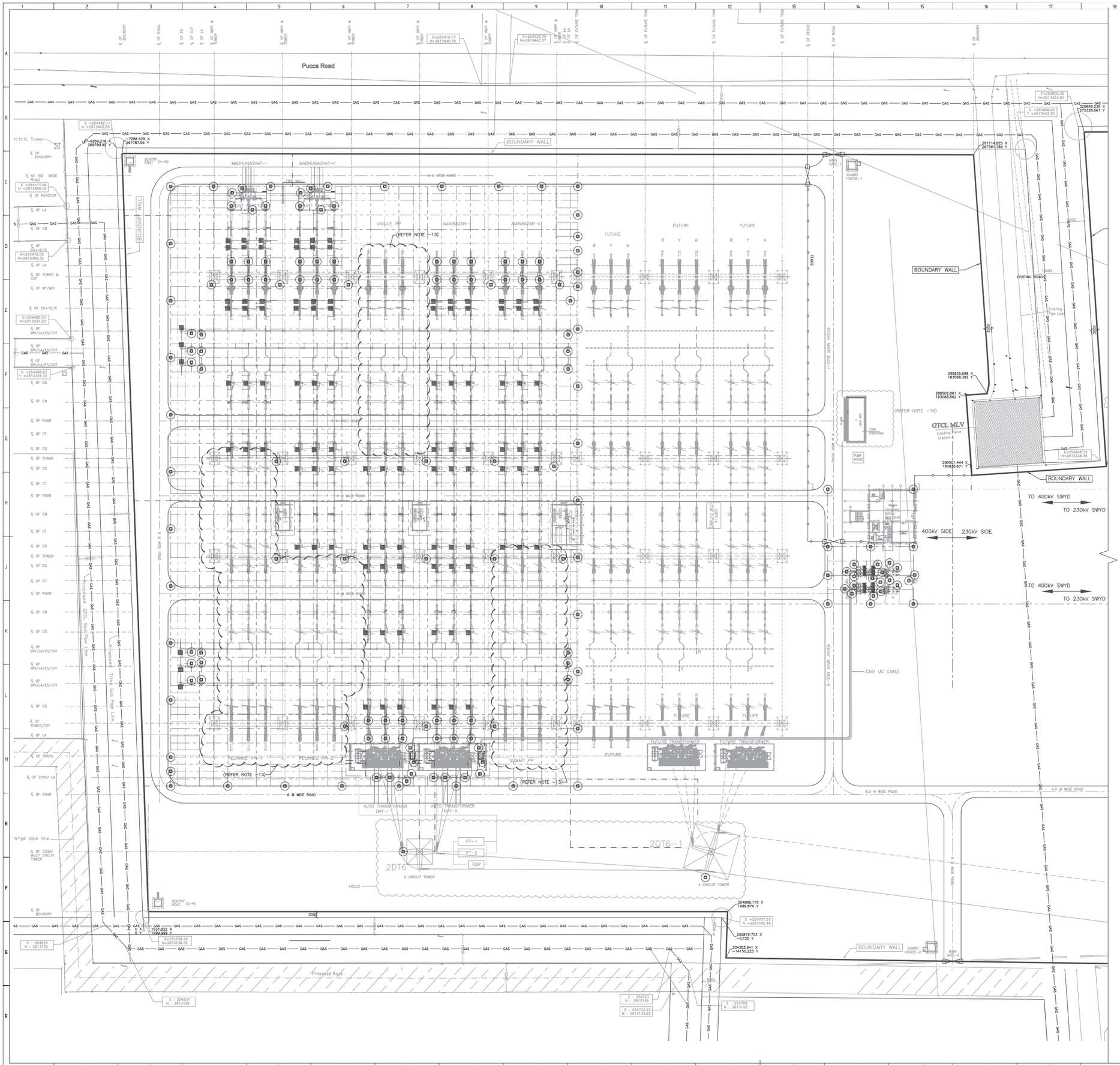
400KV SPR-1 LAYOUT PLAN

(400kV SPR-1) – PANEL

PANEL No.	DESCRIPTION
A1	(FUTURE)
A2	400kV RELAY PANEL–LIN
A3**	400kV RELAY PANEL–LIN
A4	(FUTURE)
A5	400kV RELAY PANEL–LIN
A6	400kV RELAY PANEL–LIN
A7	400kV CONTROL & TIE P
A8	400kV CONTROL & TIE P
A9	400kV BUSBAR PROTECTI
A10	400kV METERING PANEL–
A11	400kV METERING PANEL–
A12	400kV SWITCHYARD – DF
A13	400kV SWITCHYARD – DF
A14	400kV CONTROL & TIE P
A15	SUB–ACDB–1 FOR 400kV
A16	110V DCDB–1 FOR 400kV
A17	110V DCDB (F) FOR 400k
A18	400kV CONTROL & TIE P
A19	110V BATTERY – 1 FOR
A20	110V BATTERY – 2 FOR
A21	110V BATTERY CHARGER
A22	110V BATTERY CHARGER

(400kV SPR-2) – PANEL

PANEL No.	DESCRIPTION
B1	(FUTURE)
B2**	400kV RELAY PANEL–LIN
B3	400kV RELAY PANEL–ICT
B4	(FUTURE)
B5	400kV RELAY PANEL–LIN
B6	400kV RELAY PANEL–ICT
B7	400kV CONTROL & TIE P
B8	400kV CONTROL & TIE P
B9	400kV CONTROL & TIE P
B10	RTCC FOR ICT –TRAFO. E
B11	RTCC FOR ICT –TRAFO. E



NOTES:–

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL EARTHING SHALL BE DONE IN ACCORDANCE WITH IEEE:80.
3. MAIN EARTHMAT CONDUCTOR WILL BE LAID 500MM BELOW THE GROUND LEVEL.
4. EARTHING CONDUCTOR RUNNING BELOW CABLE TRENCHES, ROADS, DRAINS & RAIL SHALL BE LAID 300MM BELOW THEM.
5. THIS DRAWING IS ONLY SYMBOLIC REPRESENTATION OF EARTHING CONDUCTOR LAYOUT. AT ACTUAL SITE CONDITION, CONDUCTOR WILL BE ROUTED IN SUCH MANNER SO THAT IT DOES NOT FOUL WITH ANY FOUNDATION.
6. CABLE TRENCH EARTHING WILL BE DONE WITH 25 x 6 mm Cu FLAT AND RUN ALONG THE CABLE SUPPORTING STRUCTURE. EARTH FLAT OF CABLE TRENCH WILL BE CONNECTED TO THE MAIN EARTHING AT 30MTRS. INTERVAL AND AT BOTH ENDS. THE EARTHING FLAT FOR EHV CABLE TRENCH SHALL BE AN ADDITIONAL ITEM.
7.
8. EACH INDIVIDUAL STRUCTURE/EQUIPMENT SHOULD BE EARTHED AND CONNECTED TO TWO DIFFERENT AXIS ON THE GRID.
9.
10. INDOOR EARTHING & GIS EARTHING SHALL BE SHOWN IN A SEPARATE DRAWING.
11. MAINTENANCE FREE EARTHING SYSTEM NEEDS TO BE INSTALLED AT DESIGNATED LOCATIONS & DETAILS SHALL BE AS PER TYPICAL EARTHING DRAWING. EARTH ENHANCEMENT COMPOUND SHOULD BE TESTED AS PER IEC 62561-7.
12. FOR EQUIPMENTS TO BE INSTALLED IN EXISTING SWITCHYARD, EARTHING CONDUCTOR SHOULD BE CONNECTED TO NEAREST EXISTING EARTHMAT.
13.

existing grounding status shown only.dia -6 shall be extended with revise soil resistivity and shall include 230kv side also as per scope

LEGEND:–

- 185sq.mm. Stranded bare Copper conductor (MAIN MAT)
- 185sq.mm. Stranded bare Copper conductor (BELOW GROUND RISERS)
- 16.mm. Dia 3000MM Copper Rod
- AUXILIARY MAT

BILL OF MATERIALS (400 & 33Kv):–

SL. No.	TYPE	DESCRIPTION	QTY. in nos.	QTY. in mtrs.
1.	GRID CONDUCTOR	185sq.mm. Stranded bare Copper conductor (MAIN MAT)	–	14800
2.	RISERS BELOW GROUND LEVEL	185sq.mm. Stranded bare Copper conductor (BELOW GROUND RISERS)	–	3730
3.	ELECTRODE	16.mm. Dia 3000MM Copper Rod	169	–
4.	AUXILIARY MAT	185sq.mm. Stranded bare Copper conductor	120	2160

Employer's Approval Stamp

Title
EARTHING LAYOUT
FOR 400kV SWITCHYARD
MEGHNAGHAT

GROUNDING NOTES:–

1. The grounding notes and details shall be read in conjunction with earthmat layout drawing & technical specifications.
2. The grounding installation work shall confirm to the requirements of IEEE–80.
3. The grounding system shall have an underground grounding grid. The grounding grid shall be buried at a depth of 500mm below finished ground level.
4. An additional auxiliary grid of 1500mm x 1500mm comprising of equally spaced (300mm x 300mm) conductors at a depth of 300 mm from finished grade level shall be provided below the operating handle of isolators/ earth switches.This grid shall be connected to the main ground grid.
5. Rod electrode shall be 16 mm diameter and 3000 mm hard–drawn high conductivity Copper rod with test link driven into the ground, enclosed in concrete inspection pits, with concrete lids, installed flushed with the ground level.
6. Riser from the earth grid shall be of stranded bare copper conductor, (AS per respective conductor size)
   Riser shall rise from the ground along the nearest equipment foundation / building column / wall to avoid any obstruction in movement of personnel.
   Risers from the earth grid to the equipment/structures shall be made by two short earthing leads (one direct and another through the support structure).
   The two risers of one equipment shall be connected to two different earth mat rods which are perpendicular to each other.
7. A minimum earth in coverage of 300 mm shall be provided between the earth grid conductor and the bottom of trench/foundation/underground pipe of the crossing.
8. All earth connections above/below ground shall be done as per contract specification or as per site conditions.
9. The earth conductors at road crossing shall be laid at a depth of 300mm (min.) from the bottom of road.
10. Fence shall be earthed at every alternate post. Fence gate shall be separately earthed with flexible connection to permit movement.
11. Earth pits for electronic equipment grounding shall be distinct and not connected to any grounding conductors of any other system both above and below ground.
12. Grounding resistance of the grid shall be measured after connecting all the electrodes to the grid. The resistance between any point on the metallic earth grid and the general mass of earth shall not exceed 0.5 ohm during dry season.
13. Ground conductor around the building shall be buried in earth at a minimum distance of 1500mm from the outer boundary of the building.
14. Down conductor of lightning mast and towers with peak, earthing terminal of each lightning arrester and CVT shall be connected via test link to rod electrode with test pit. Rod Electrode, shall be in turn, connected to earth grid.

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR CU EARTHING		03	

SHEET SIZE : A4 (210 x 297)

GROUNDING NOTES:–

15. Cu flat of size 25 x 6 mm shall run on top tier all along the cable trench and clamped to each of the racks. Cu flat shall be earthed at an interval of 30 mtrs. and also at both ends.
16. All electrical equipment and associated non–current carrying metal works, supporting structures, building columns, fence, system neutrals shall be connected to the substation main grounding system.
17. Earthing conductors embedded in the concrete floor of the building shall have approximately 50mm concrete cover.
18. Metallic sheaths, screens and armour of all multicore cables shall be earthed at both equipment and switchboard ends. Sheath and armour of single core power cables shall be earthed at switchboard end only.
19. Miscellaneous devices such as junction boxes, pull boxes, push button station, lockout switches, cable and boxes etc. shall be effectively earthed whether specifically shown or not.
20. For earth connections, the conductor sizes shall be as listed below–

GROUNDING CONDUCTOR DETAILS :–

Sl. No.	DESCRIPTION	CONDUCTOR DETAILS
a)	MAIN MAT	185sq.mm. Stranded bare Copper conductor
b)	RISERS BELOW GROUND LEVEL	185sq.mm. Stranded bare Copper conductor
c)	RISERS ABOVE GROUND LEVEL	185sq.mm. Stranded bare Copper conductor
d)	AUXILIARY MAT	185sq.mm. Stranded bare Copper conductor
e)	EARTHING OF INDOOR LT PANELS, C & R PANELS AND OUTDOOR MARSHALLING BOXES, MOM BOXES, JUNCTION BOXES AND LIGHTING PANELS, CABLE TRENCHES, ETC.	25 x 6 mm Cu FLAT

21. All joints with earthing grid conductor, which are buried underground and not in the earthing pit shall be done by exothermic joint.

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS COMMON NOTES & LEGEND		04	

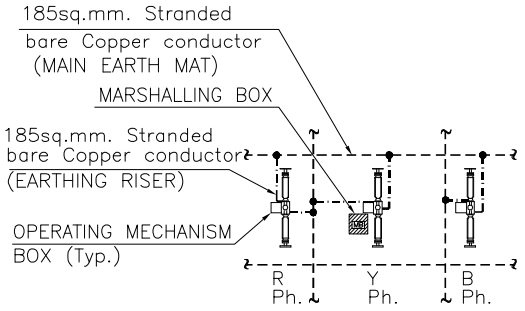
SHEET SIZE : A4 (210 x 297)

DESCRIPTIO	3ø QTY.
RISER FOR EQU & STRU–2Nos./PHASE	.

LEGEND:–

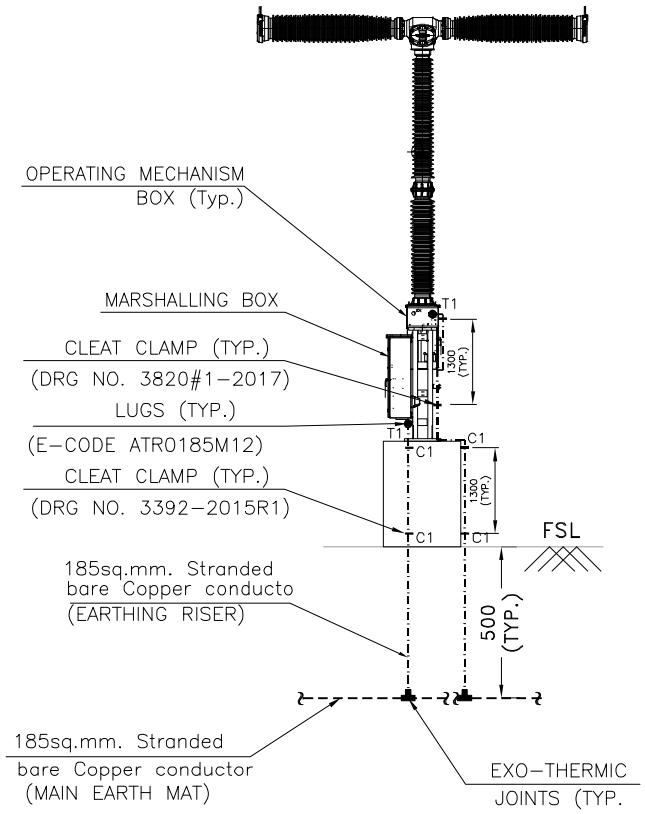
185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats, .



ELEVATION

400kV CIRCUIT BREAKER

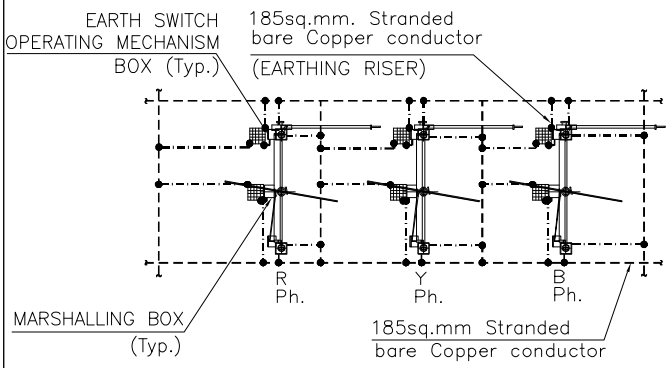
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV CIRCUIT BREAKER		05	

SHEET SIZE : A4 (210 x 297)

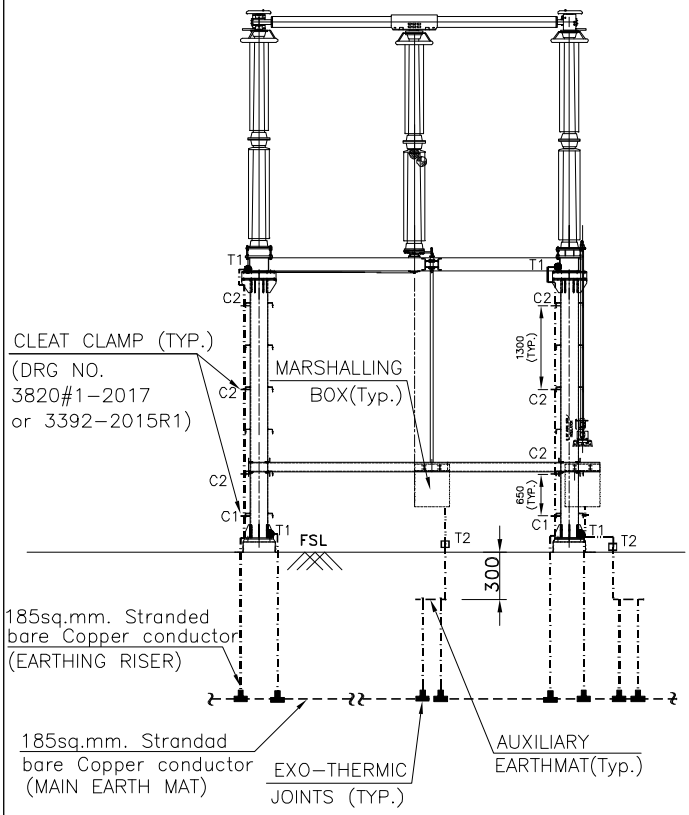
LEGEND:–

- 185sq.mm. Stranded bare Copper conductor
- 185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
- 25 x 6 mm Cu FLAT



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION
400kV ISOLATOR WITH 1 E/S

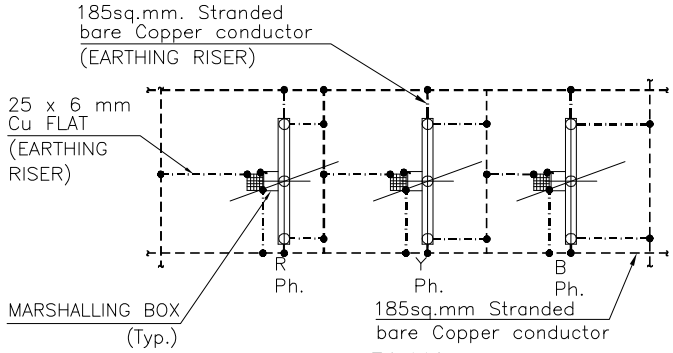
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV ISOLATOR WITH 1 EARTH SWITCH		06	

SHEET SIZE : A4 (210 x 297)

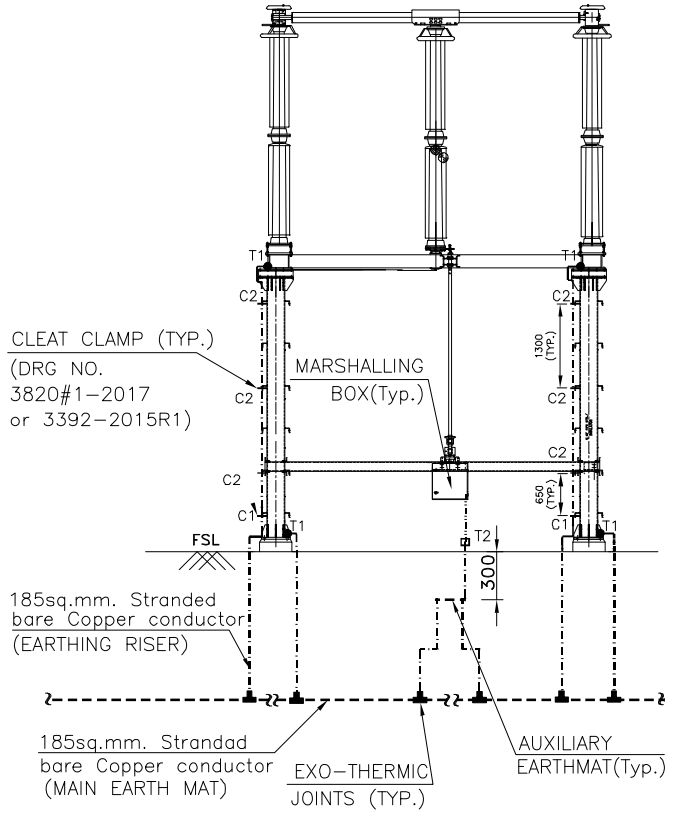
LEGEND:–

- ---------- 185sq.mm. Stranded bare Copper conductor
- –·–·–·–·– 185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
- –··–··–··– 25 x 6 mm Cu FLAT



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION

400kV ISOLATOR WITHOUT E/S

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

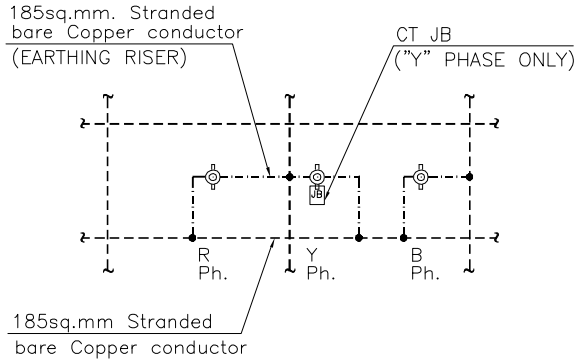
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV ISOLATOR WITHOUT EARTH SWITCH		07	

SHEET SIZE : A4
(210 x 297)

LEGEND:–

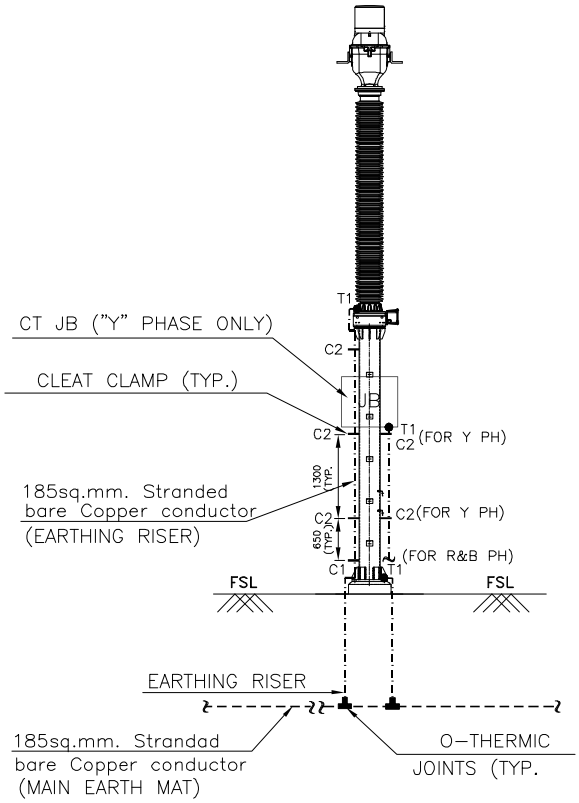
185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



DWG : Earthing accessories drawings – Clamps, Joints & Cleats,

PLAN



ELEVATION

400kV CURRENT TRANSFORMER

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

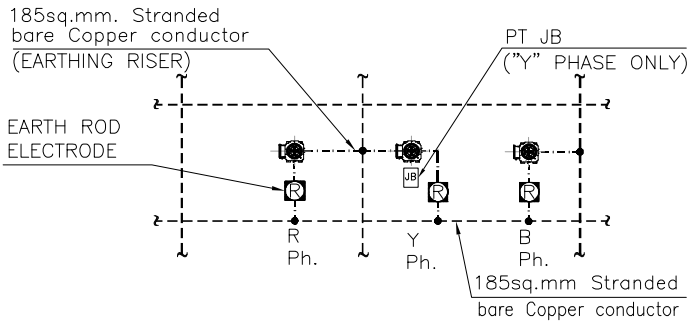
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV CURRENT TRANSFORMER		08	

SHEET SIZE : A4 (210 x 297)

LEGEND:–

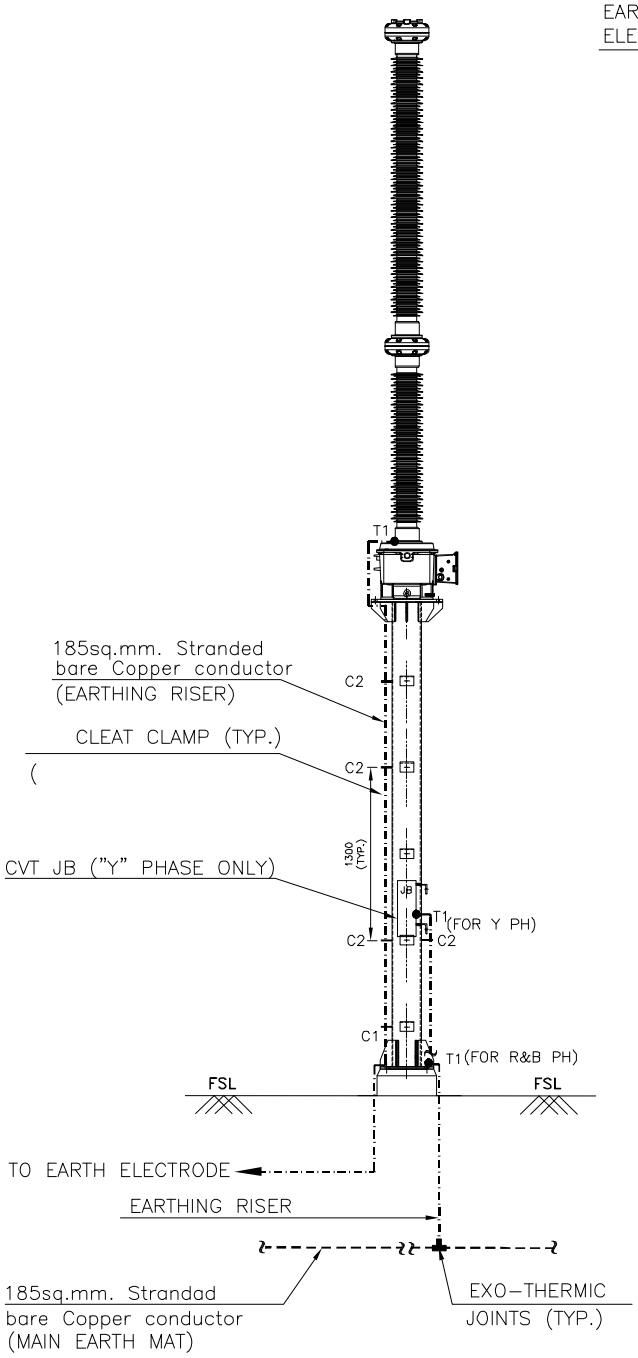
185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION

400kV CAPACITIVE VOLTAGE TRANSFORMER

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

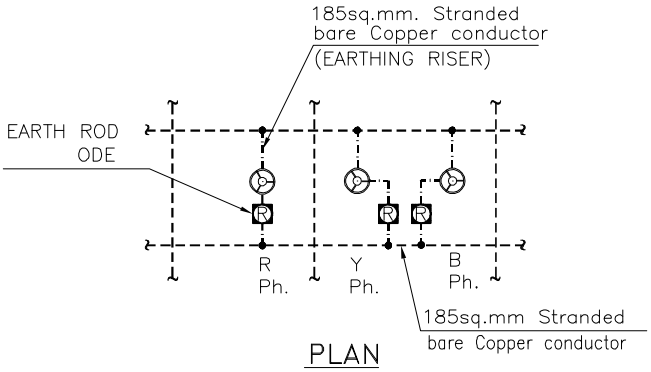
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TYPICAL EARTHING DETAILS FOR 400kV CAPACITIVE VOLTAGE TRANSFORMER		09	

SHEET SIZE : A4 (210 x 297)

LEGEND:–

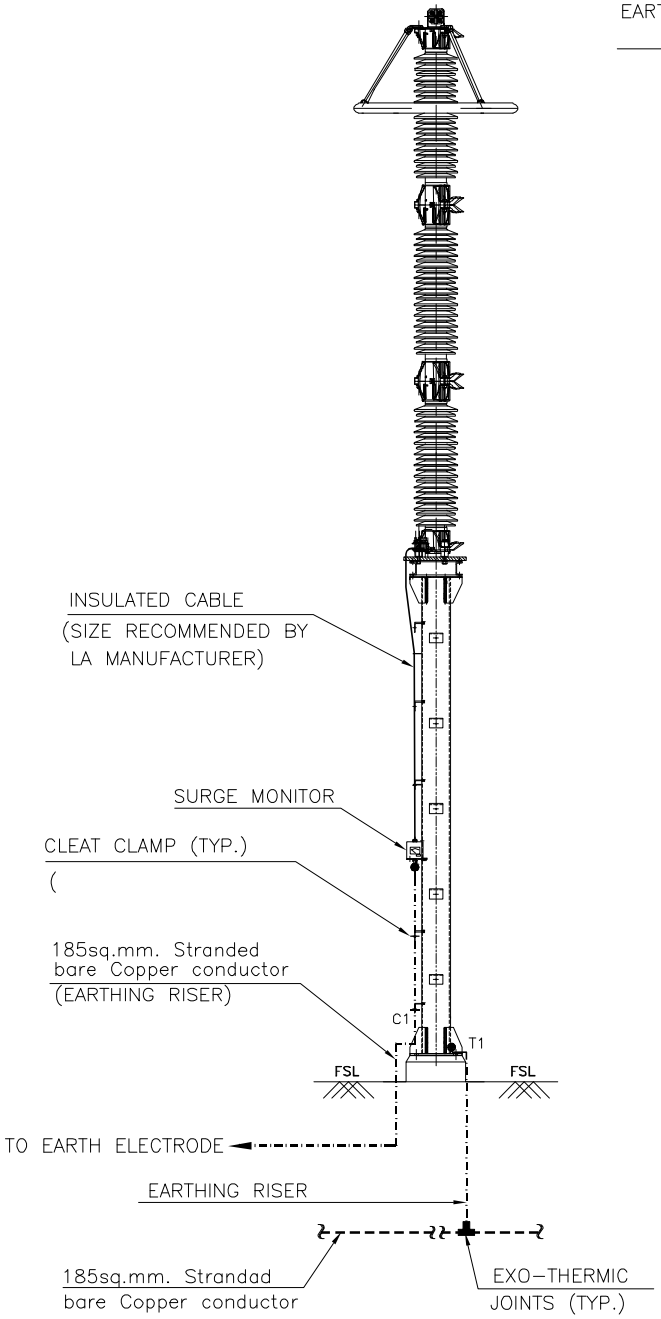
185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION
400kV LIGHTNING ARRESTER

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

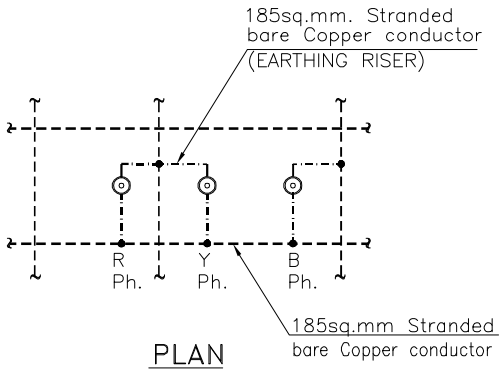
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TYPICAL EARTHING DETAILS FOR 400kV LIGHTNING ARRESTER		10	

SHEET SIZE : A4
(210 x 297)

LEGEND:–

185sq.mm. Stranded bare Copper conductor

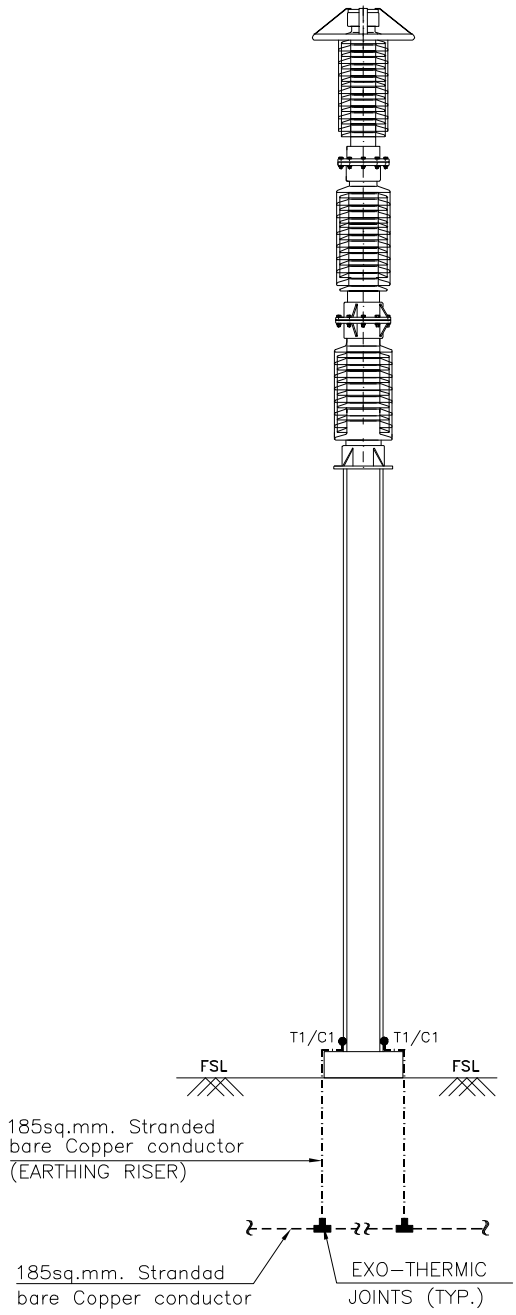
185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,

R



ELEVATION

400kV LOW/HIGH POST INSULATOR

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

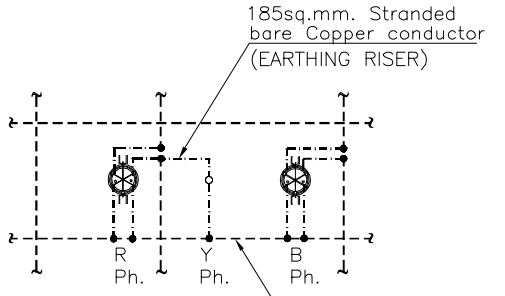
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV 400kV LOW/HIGH POST INSULATOR		11	

SHEET SIZE : A4 (210 x 297)

LEGEND:–

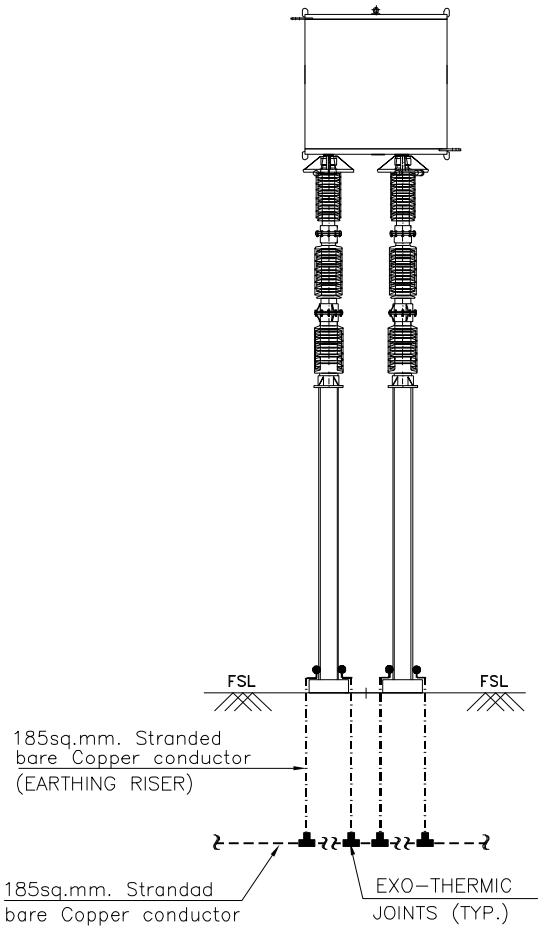
185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN

REFER DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION

400kV WT

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV WT		12	

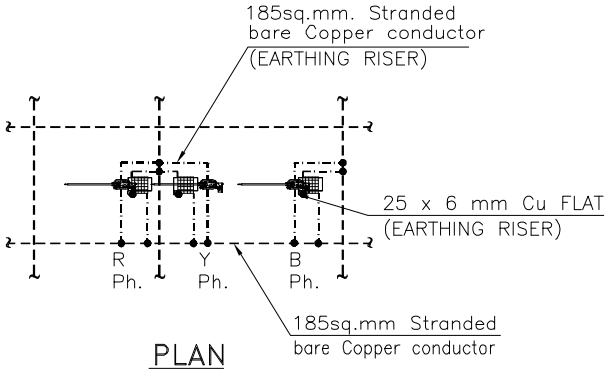
SHEET SIZE : A4 (210 x 297)

LEGEND:–

185sq.mm. Stranded bare Copper conductor

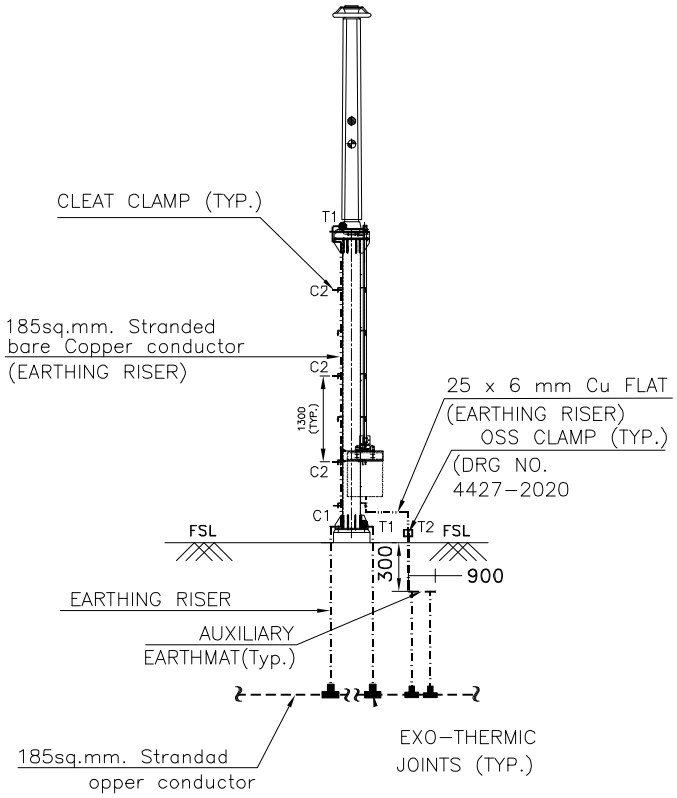
185sq.mm. Stranded bare Copper conductor (EARTHING RISER)

25 x 6 mm Cu FLAT



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION
400kV EARTH SWITCH

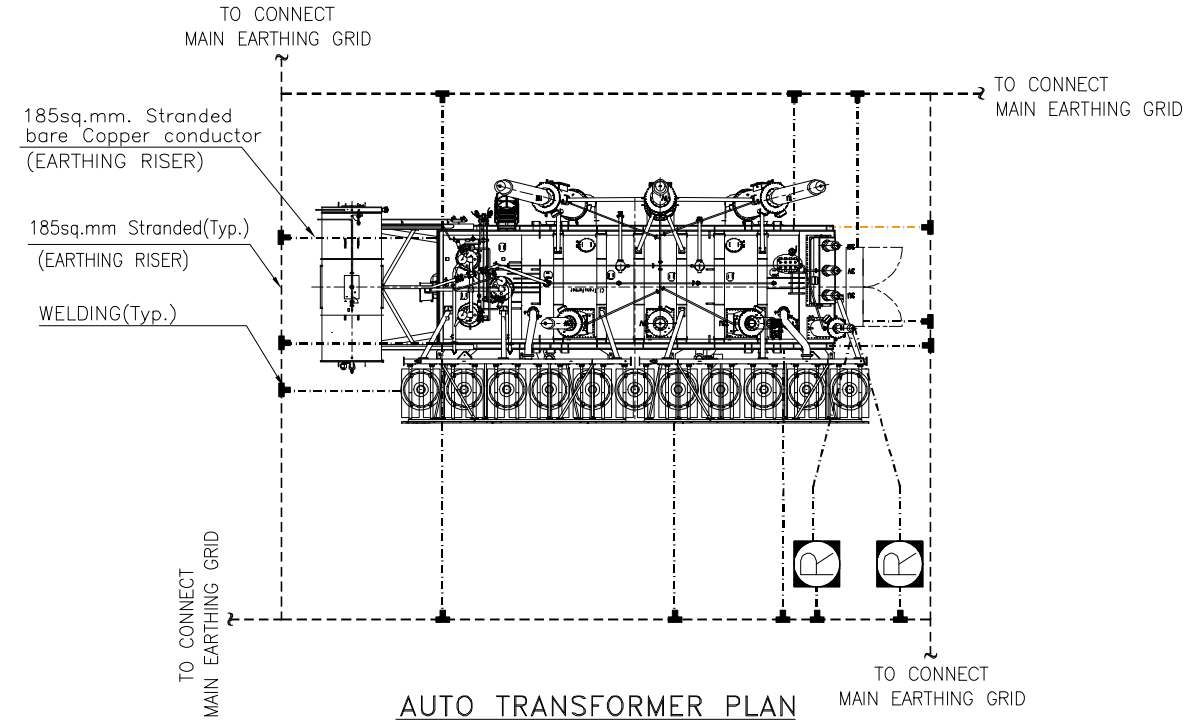
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV EARTH SWITCH		13	

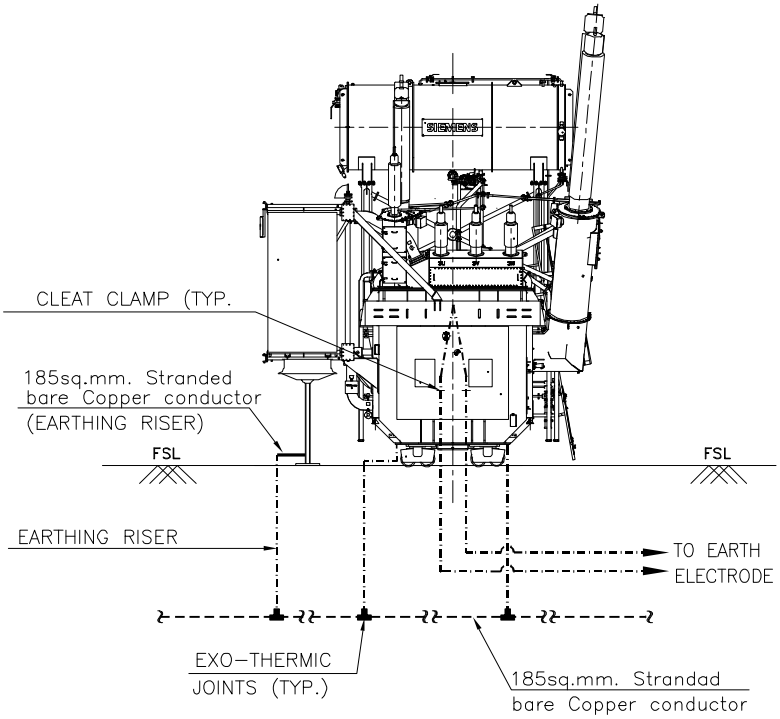
SHEET SIZE : A4 (210 x 297)

LEGEND:–

- 185sq.mm. Stranded bare Copper conductor
- 185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
- 25 x 6 mm Cu FLAT



AUTO TRANSFORMER PLAN



AUTO TRANSFORMER SECTION

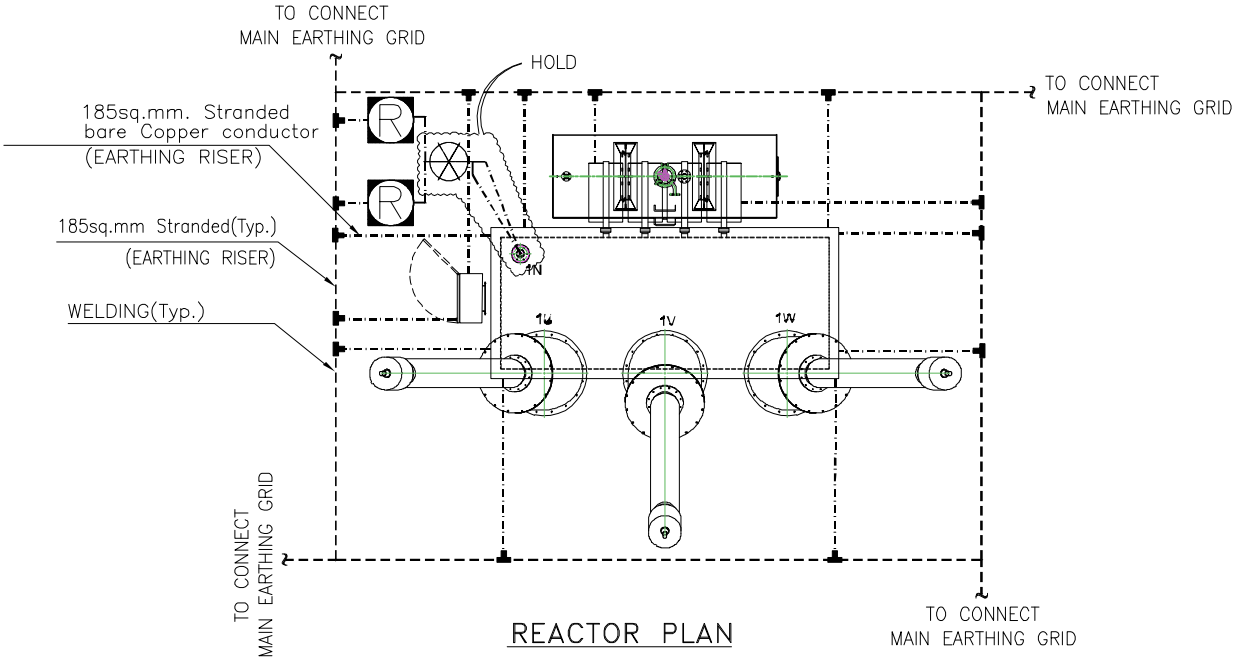
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR AUTO TRANSFORMER		14	

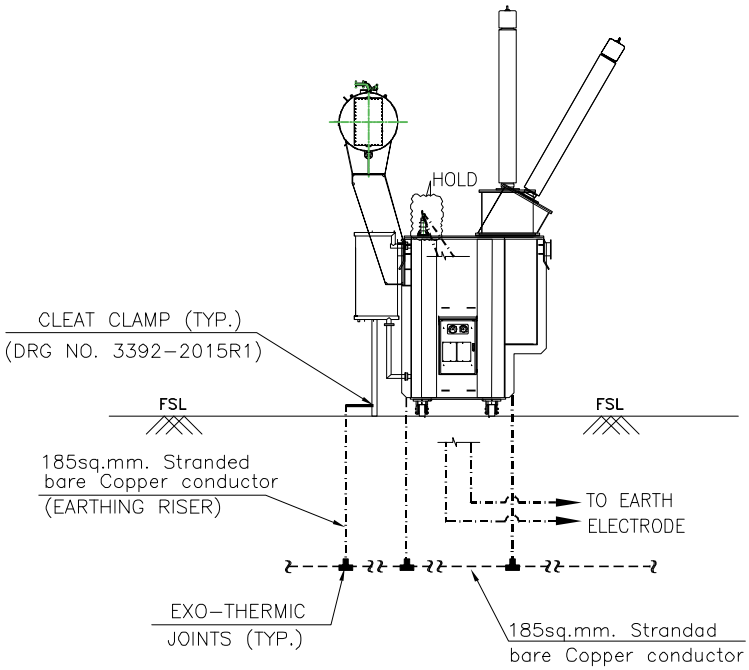
SHEET SIZE : A4
(210 x 297)

LEGEND:–

- 185sq.mm. Stranded bare Copper conductor
- 185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
- 25 x 6 mm Cu FLAT



REACTOR PLAN



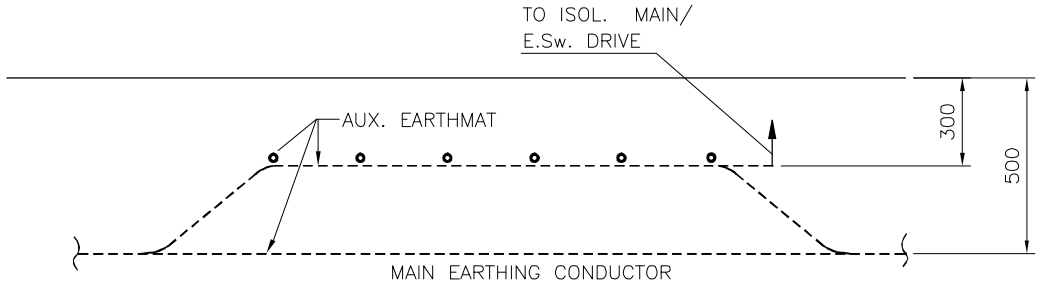
REACTOR SECTION

	400kV/230kV MEGHNAGHAT SUBSTAION POWER GRID COMPANY OF BANGLADESH LTD.	
L		
TITLE: TYPICAL EARTHING DETAILS FOR 400KV REACTOR	DRAWING NO.:	SHEET No. 15 / REV.

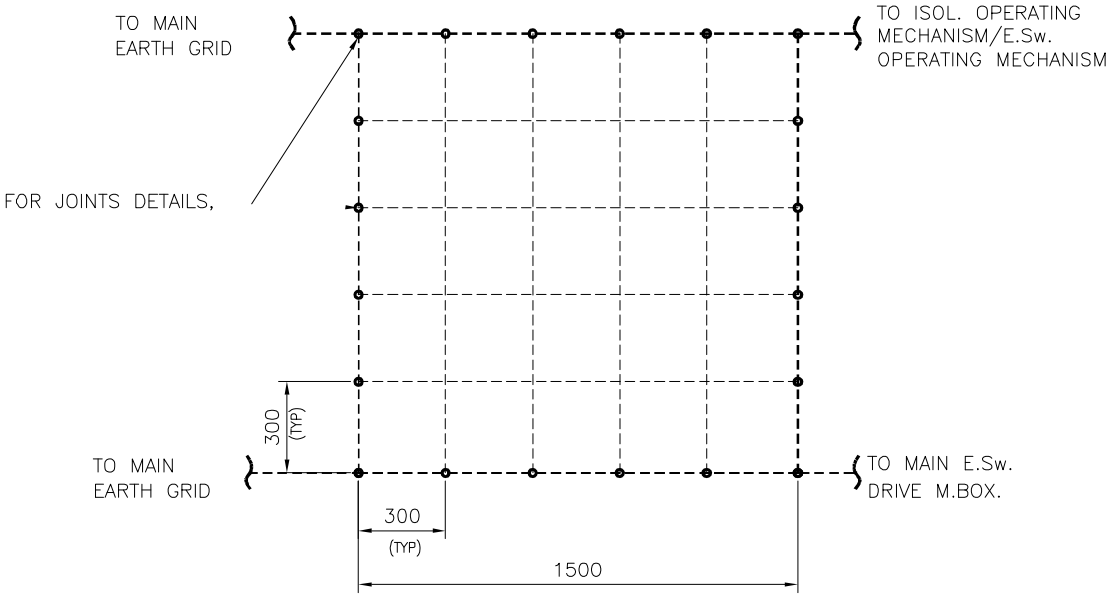
SHEET SIZE : A4 (210 x 297)

LEGEND:–

---------- 185sq.mm. Stranded bare Copper conductor



ELEVATION



PLAN

DETAILS OF AUXILIARY EARTHMAT

	400kV/230kV MEGHNAGHAT SUBSTAION POWER GRID COMPANY OF BANGLADESH LTD.		
TITLE: TYPICAL EARTHING DETAILS FOR 400KV ISOLATOR AUXILIARY EARTH MAT	DRAWING NO.:	SHEET No. 16	REV.

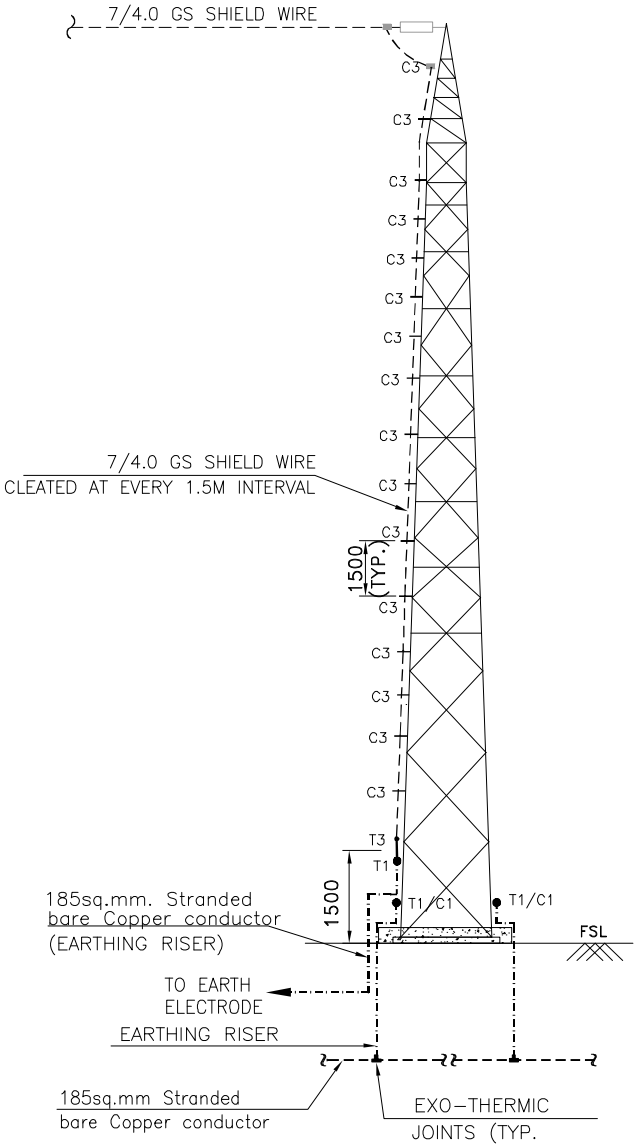
SHEET SIZE : A4
(210 x 297)

LEGEND:–

185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)

7/4.0 GS SHIELD WIRE



TOWER WITH PEAK

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 400kV TOWER WITH PEAK		17	

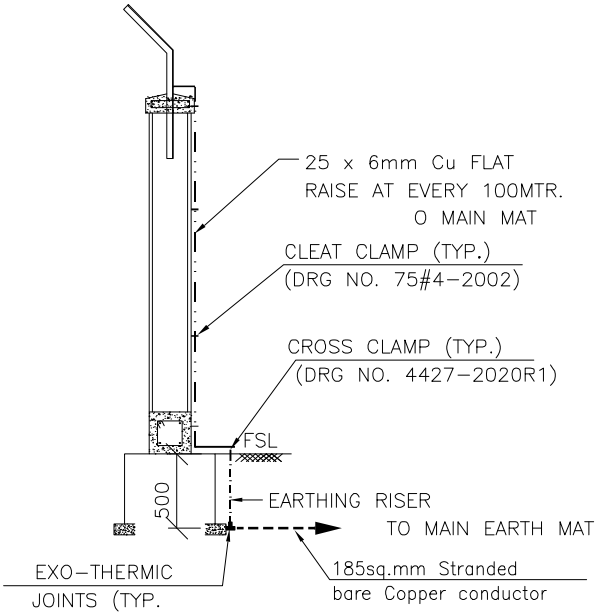
SHEET SIZE : A4 (210 x 297)

LEGEND:–

185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)

25 x 6 mm Cu FLAT



GROUNDING DETAIL OF BOUNDARY WALL

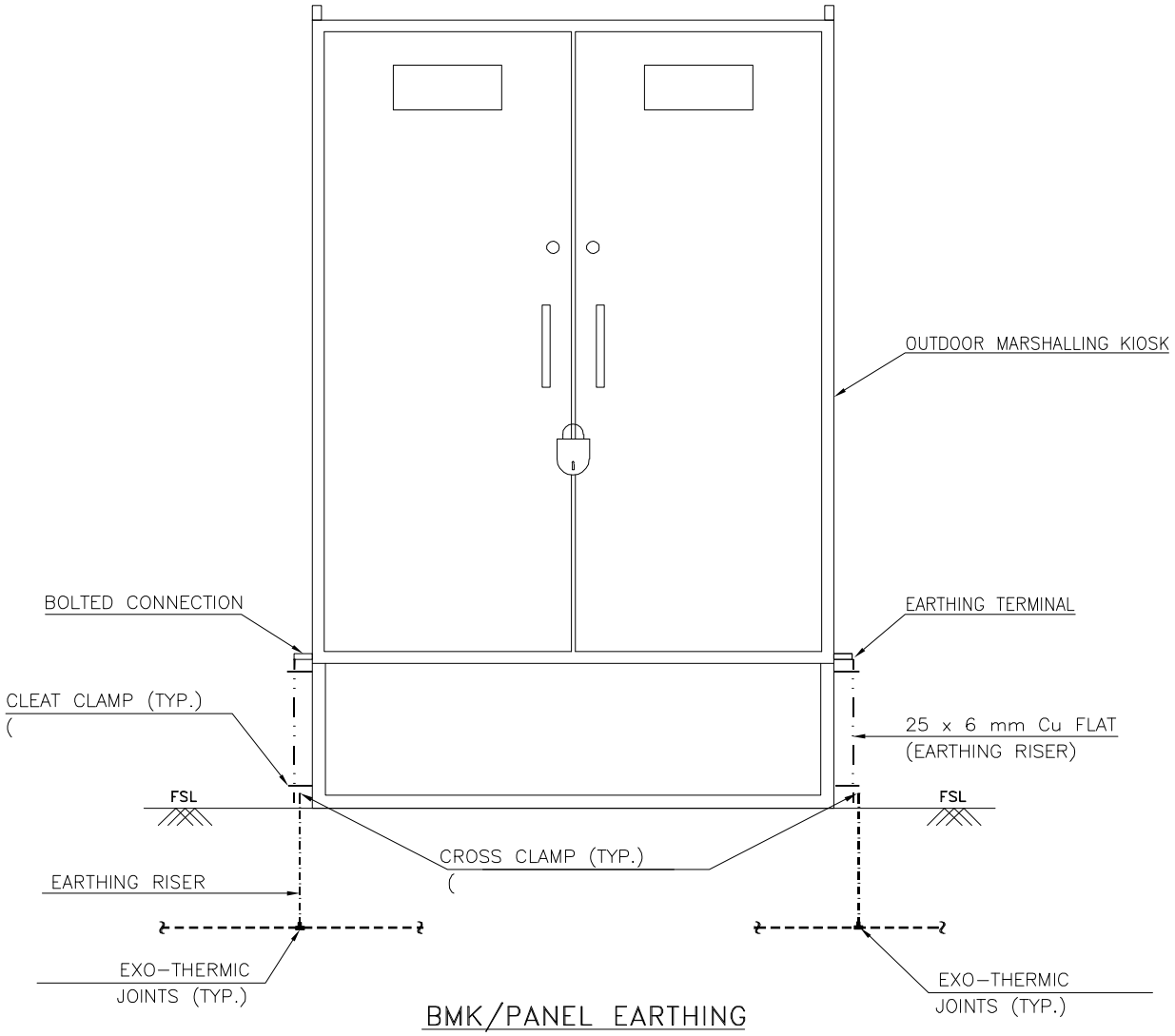
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR BOUNDARY WALL		18	

SHEET SIZE : A4
(210 x 297)

LEGEND:–

----------	185sq.mm. Stranded bare Copper conductor
–·–·–·–·–	185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
–·–·–·–·–	25 x 6 mm Cu FLAT



BMK/PANEL EARTHING

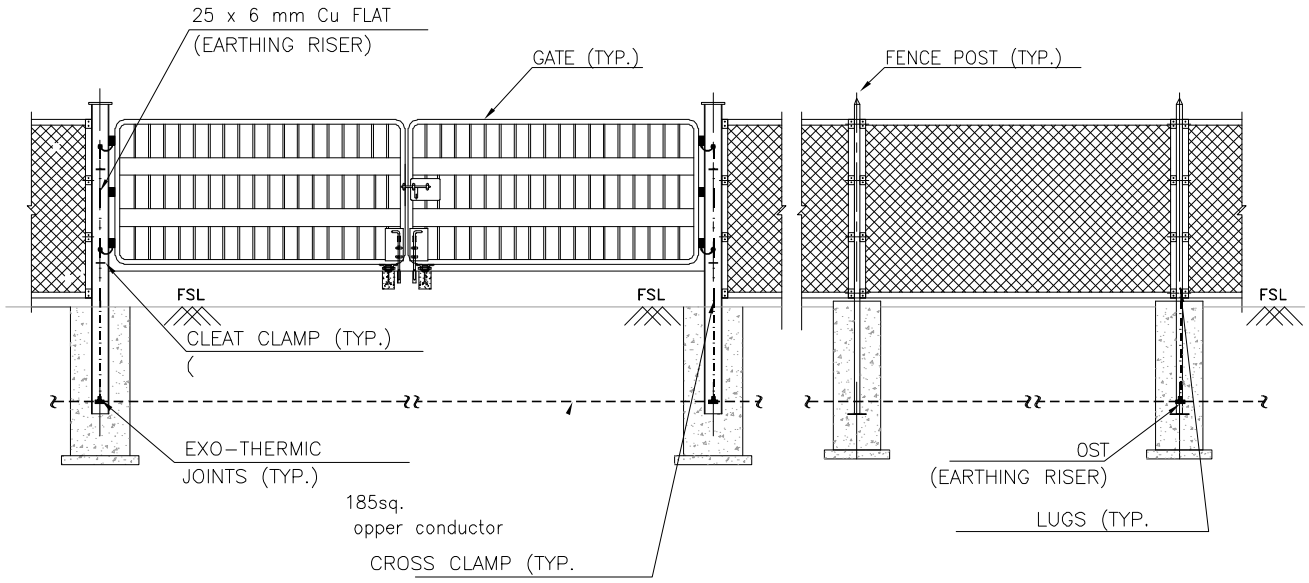
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR BMK/PANEL		19	

SHEET SIZE : A4
(210 x 297)

LEGEND:–

----------	185sq.mm. Stranded bare Copper conductor
–·–·–·–·–	185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
–·–·–·–·–	25 x 6 mm Cu FLAT



TYPICAL ELEVATION OF GATE

TYPICAL ELEVATION OF FENCE

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

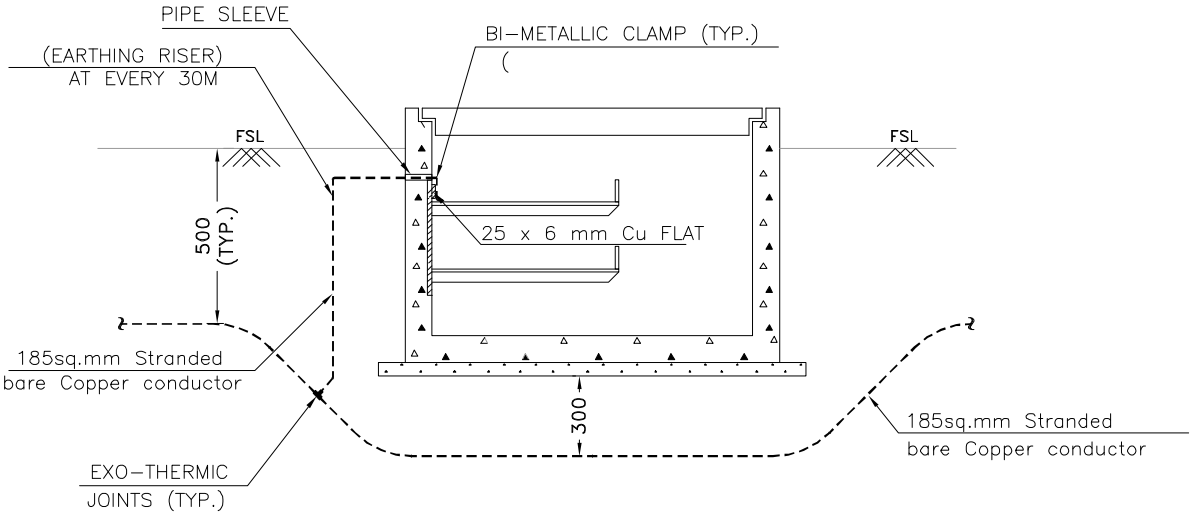
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR GATE AND FENCE		20	

SHEET SIZE : A4
(210 x 297)

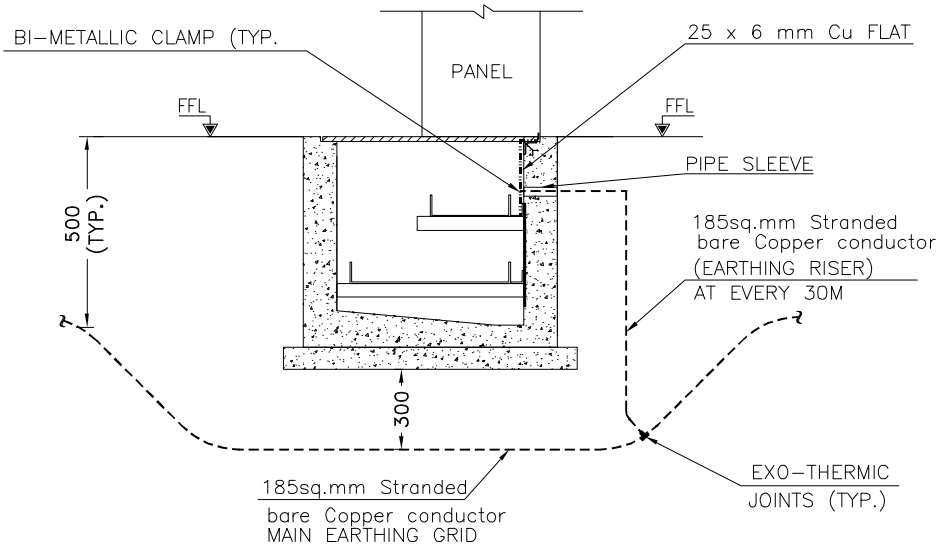
LEGEND:–

185sq.mm. Stranded bare Copper conductor

25 x 6 mm Cu FLAT



CABLE TRENCH CROSSING & GROUNDING



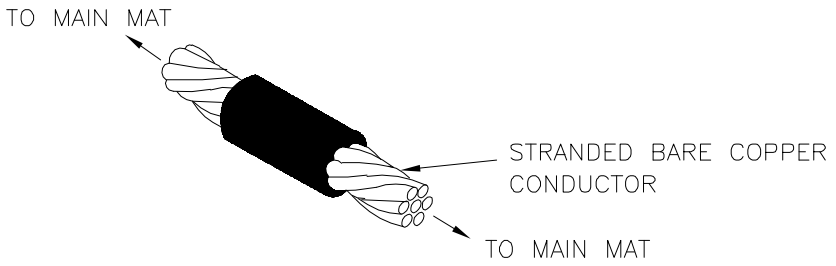
INDOOR CABLE TRENCH EARTHING

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

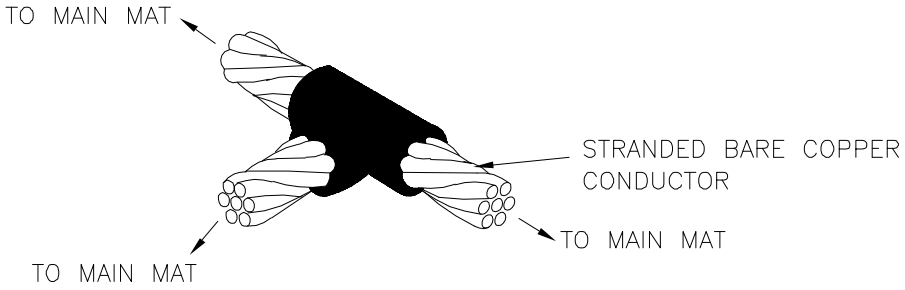
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR CABLE TRAYS/TRENCHES		21	

SHEET SIZE : A4
(210 x 297)

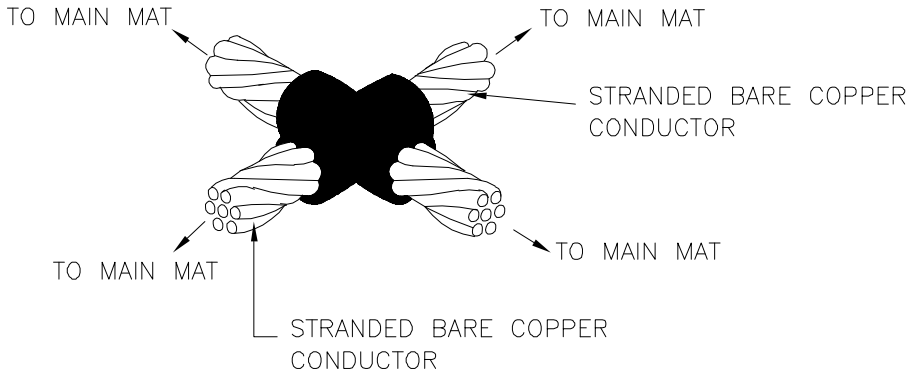
DETAIL OF HORIZONTAL CONNECTION JOINTS



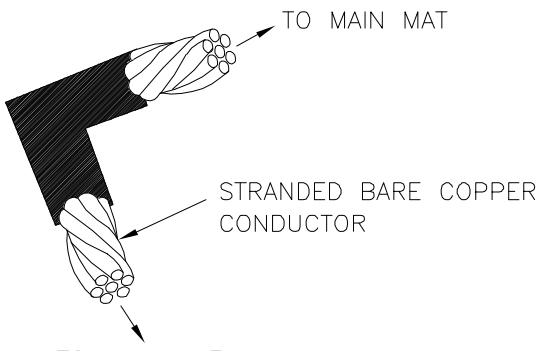
DETAIL OF T CONNECTION JOINTS



DETAIL OF CROSS CONNECTION JOINTS



DETAIL OF 90° CONNECTION JOINTS

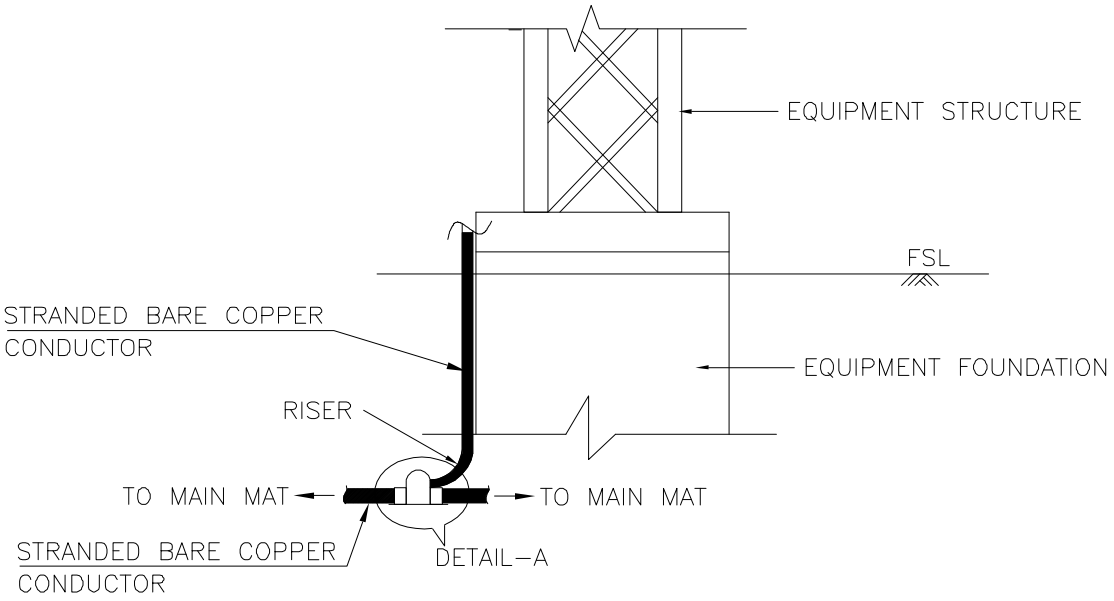


400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

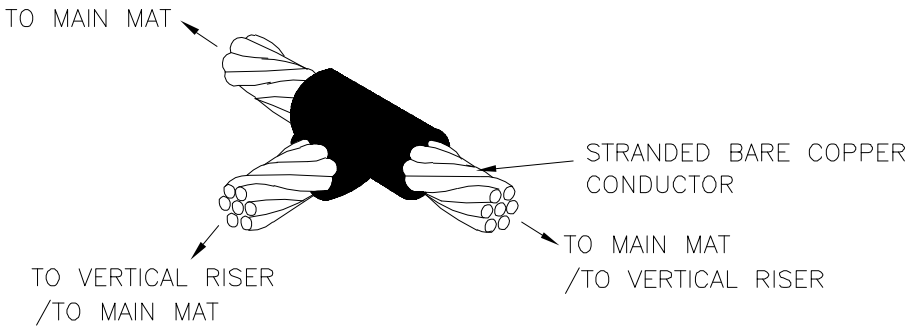
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR EXO-THERMIC JOINTS		22	

SHEET SIZE : A4
(210 x 297)

Typical Detail of Riser



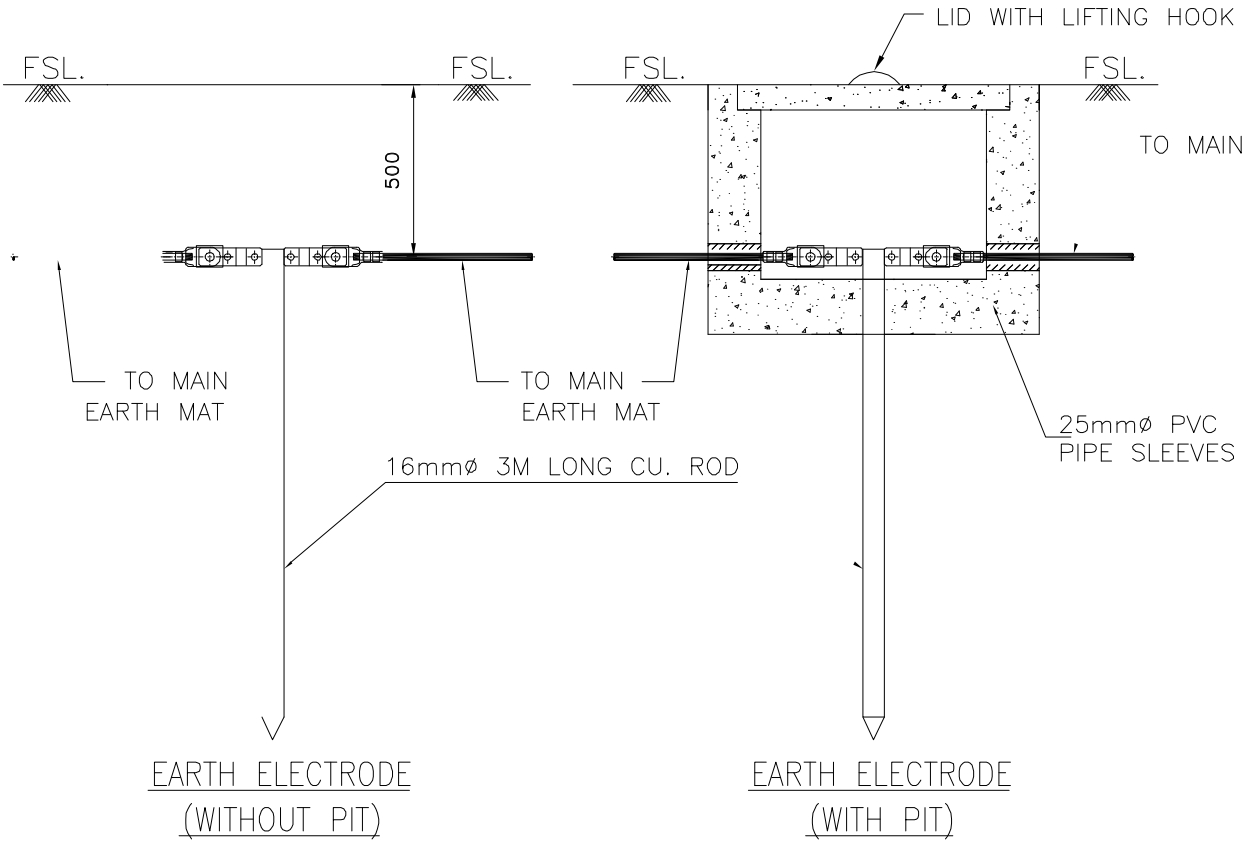
DETAIL OF T CONNECTION JOINTS

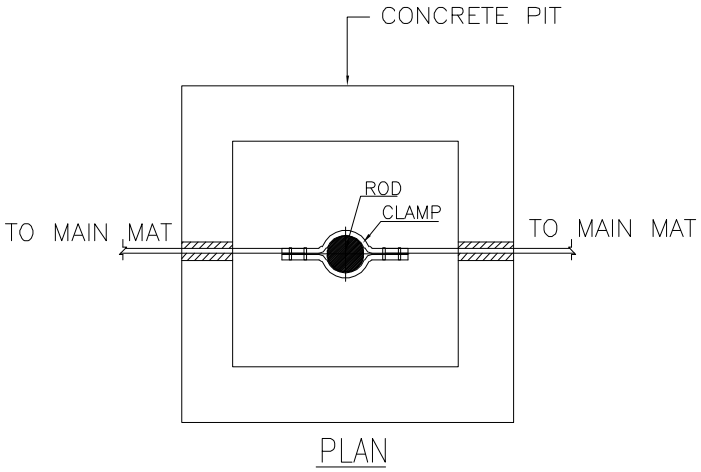


DETAIL–A

400kV/230kV MEGHNAGHAT SUBSTAION POWER GRID COMPANY OF BANGLADESH LTD.			
TITLE: TYPICAL EARTHING DETAILS FOR RISER	DRAWING NO.:	SHEET No. 23	REV.

SHEET SIZE : A4
(210 x 297)





GROUNDING DETAIL OF EARTHING ELECTRODE

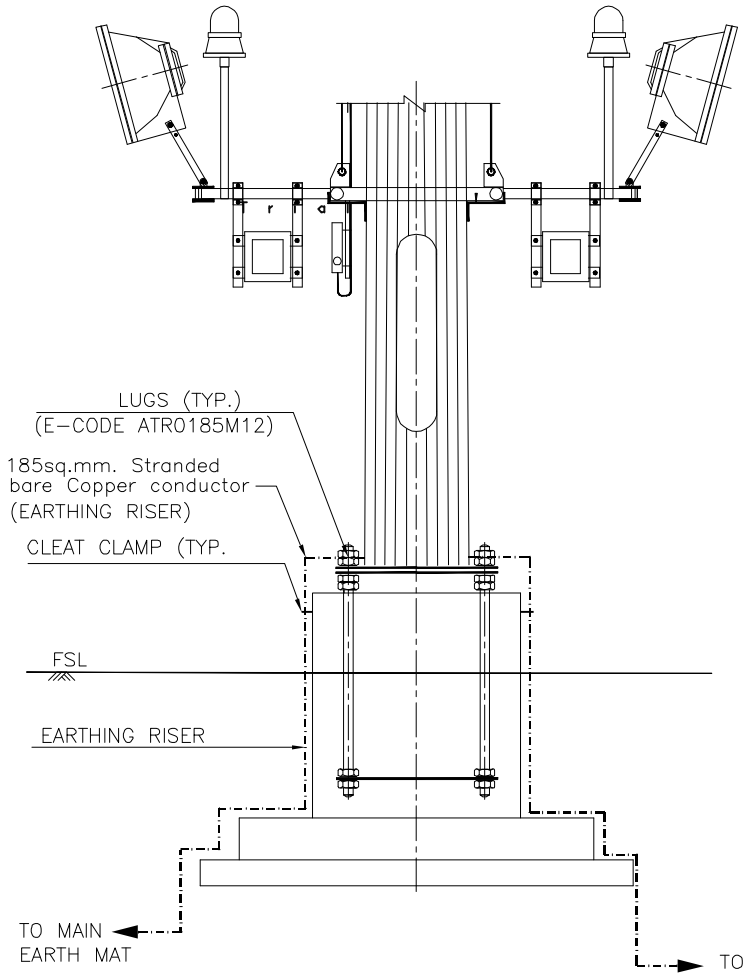
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR EARTH ELECTRODE		24	

SHEET SIZE : A4
(210 x 297)

LEGEND:–

----------	185sq.mm. Stranded bare Copper conductor
–·–·–·–·–	185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
–·–·–·–·–	25 x 6 mm Cu FLAT



GROUNDING DETAIL OF LIGHTING cum LIGHTNING MAST (LCLM)

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

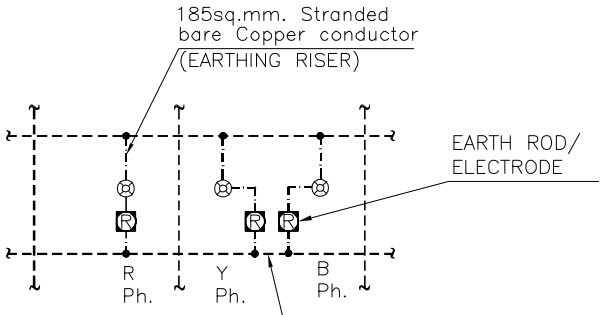
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAIL FOR LIGHTING cum LIGHTNING MAST (LCLM)		25	

SHEET SIZE : A4
(210 x 297)

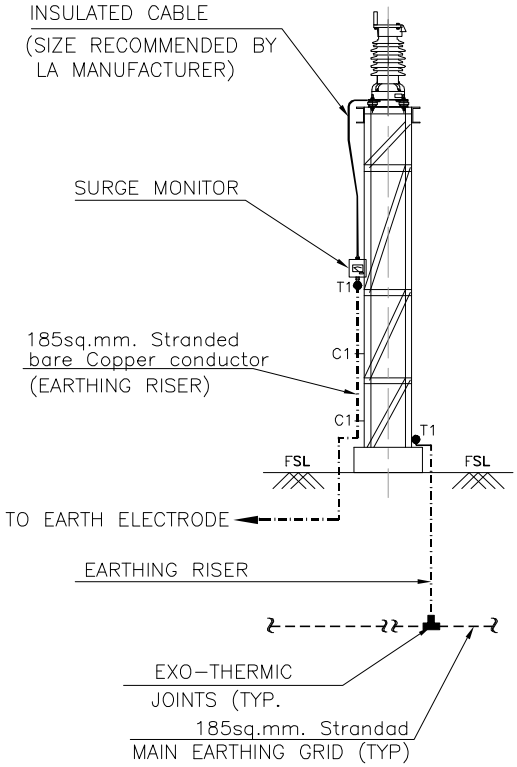
LEGEND:–

185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN



ELEVATION
33kV LIGHTNING ARRESTER

DWG : Earthing accessories drawings
– Clamps, Joints & Cleats,

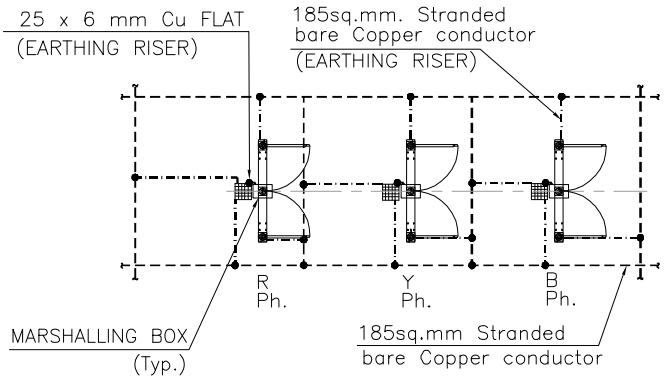
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 33kV LIGHTNING ARRESTER		26	

SHEET SIZE : A4
(210 x 297)

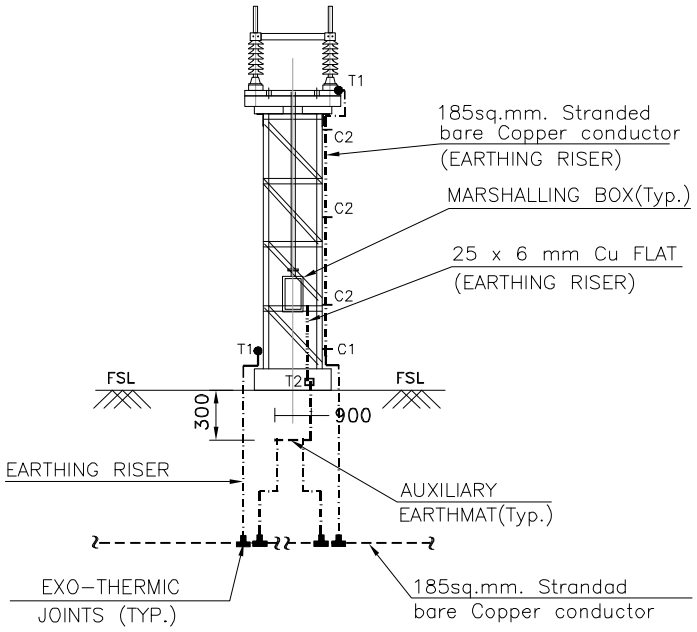
LEGEND:–

- 185sq.mm. Stranded bare Copper conductor
- 185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
- 25 x 6 mm Cu FLAT



PLAN

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,



ELEVATION
33kV DISCONNECTOR

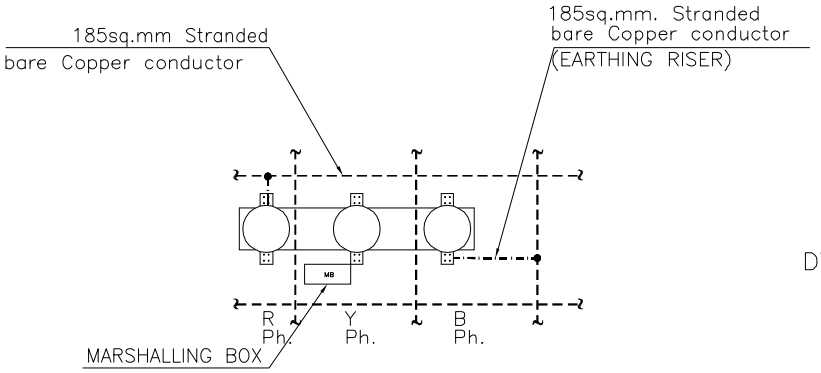
	400kV/230kV MEGHNAGHAT SUBSTAION POWER GRID COMPANY OF BANGLADESH LTD.	
TITLE: TYPICAL EARTHING DETAILS FOR 33kV DISCONNECTOR	DRAWING NO.:	SHEET No. / REV.

SHEET SIZE : A4 (210 x 297)

LEGEND:–

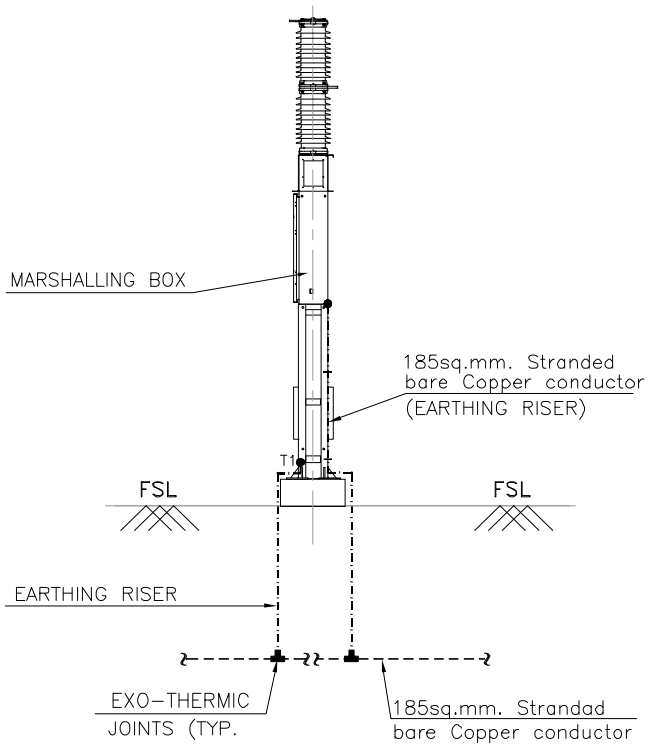
185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN

DWG : Earthing accessories drawings
– Clamps, Joints & Cleats,



ELEVATION

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

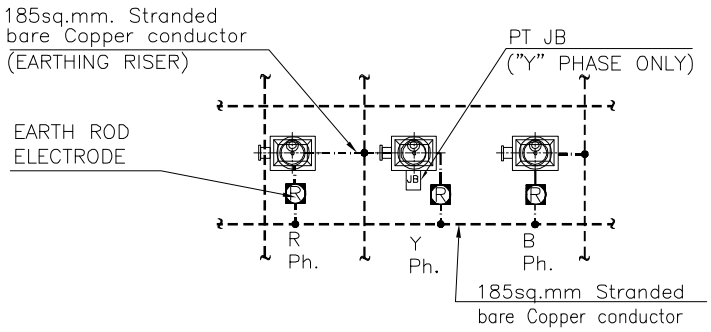
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 33kV CIRCUIT BREAKER		8	

SHEET SIZE : A4
(210 x 297)

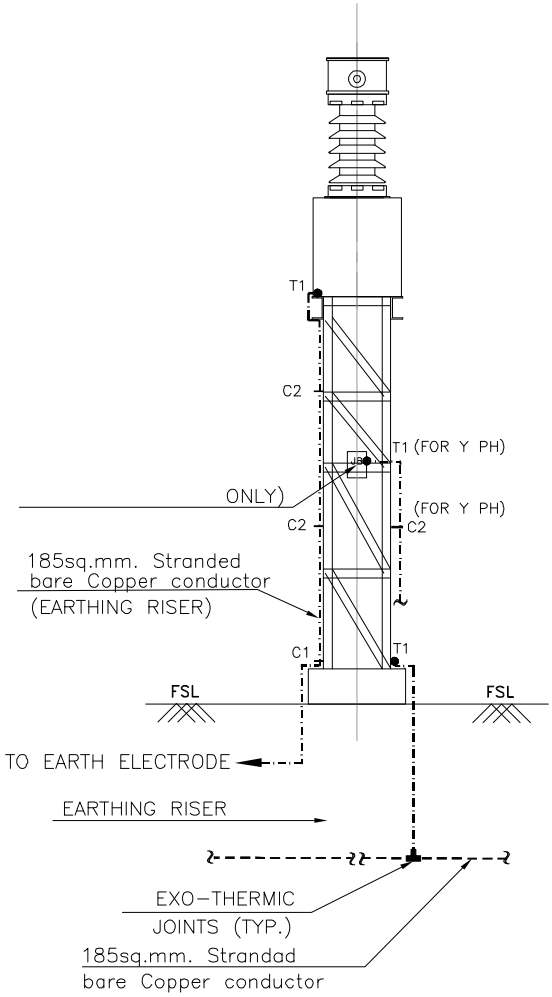
LEGEND:–

185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



PLAN



ELEVATION

33kV IVT

DWG : Earthing accessories drawings – Clamps, Joints & Cleats,

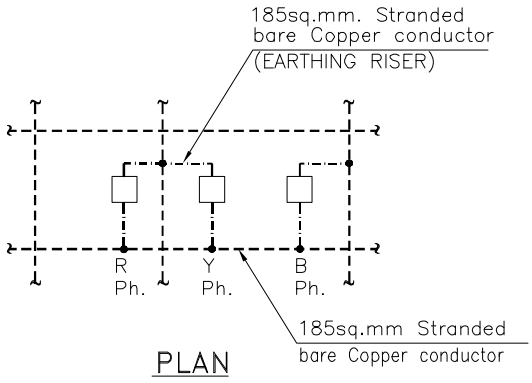
400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 33kV IVT		29	

SHEET SIZE : A4 (210 x 297)

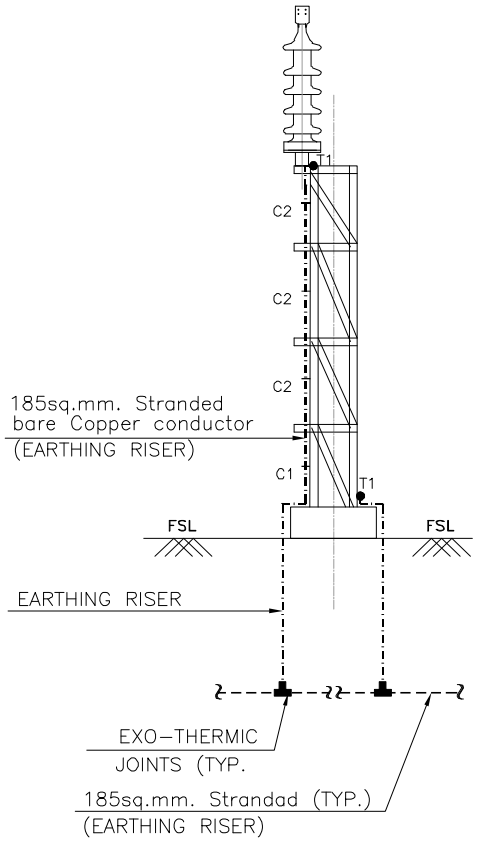
LEGEND:–

- 185sq.mm. Stranded bare Copper conductor
- 185sq.mm. Stranded bare Copper conductor (EARTHING RISER)
- 25 x 6 mm Cu FLAT



PLAN

DWG : Earthing accessories drawings
– Clamps, Joints & Cleats,



ELEVATIO

33kV CABLE TERMINATION UNIT

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

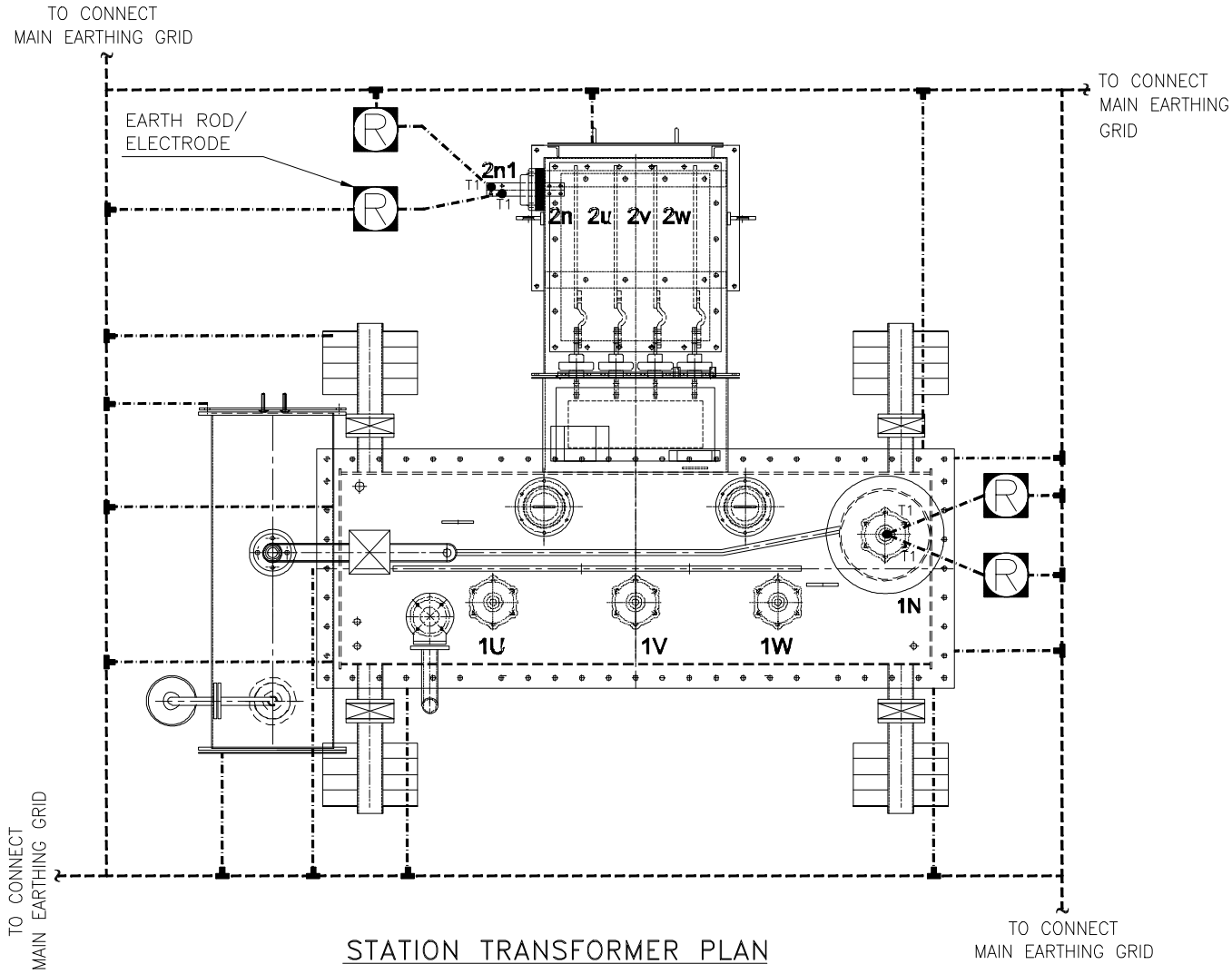
TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 33kV CABLE TERMINATION UNIT		30	

SHEET SIZE : A4
(210 x 297)

LEGEND:–

185sq.mm. Stranded bare Copper conductor

185sq.mm. Stranded bare Copper conductor (EARTHING RISER)



STATION TRANSFORMER PLAN

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR STATION TRANSFORMER		31	4

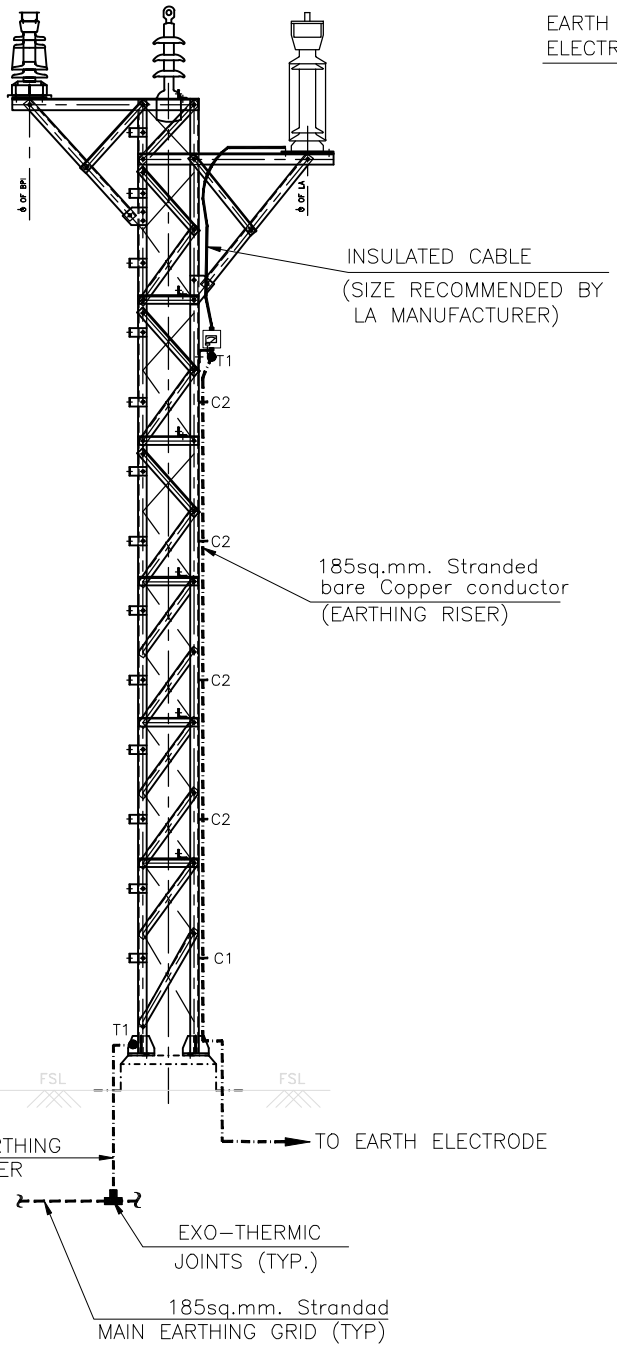
SHEET SIZE : A4 (210 x 297)

LEGEND:–

185sq.mm. Stranded bare Copper conductor

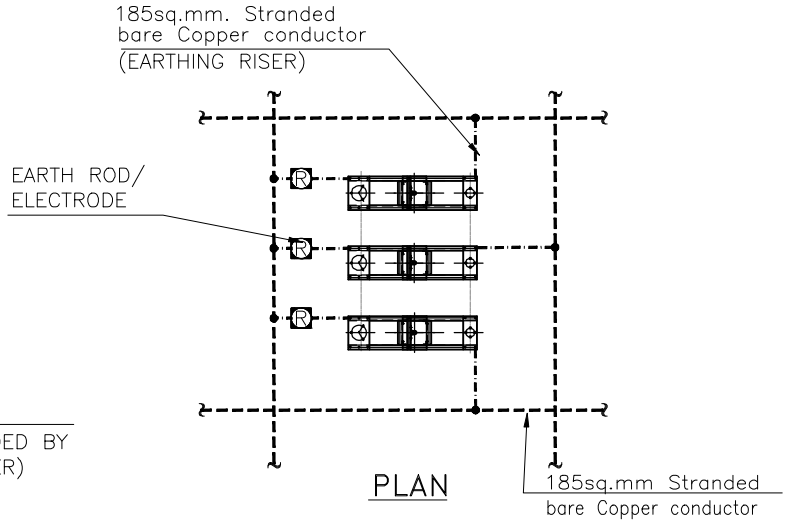
185sq.mm. Stranded bare Copper conductor (EARTHING RISER)

25 x 6 mm Cu FLAT



ELEVATION

33kV CABLE TERMINATION UNIT



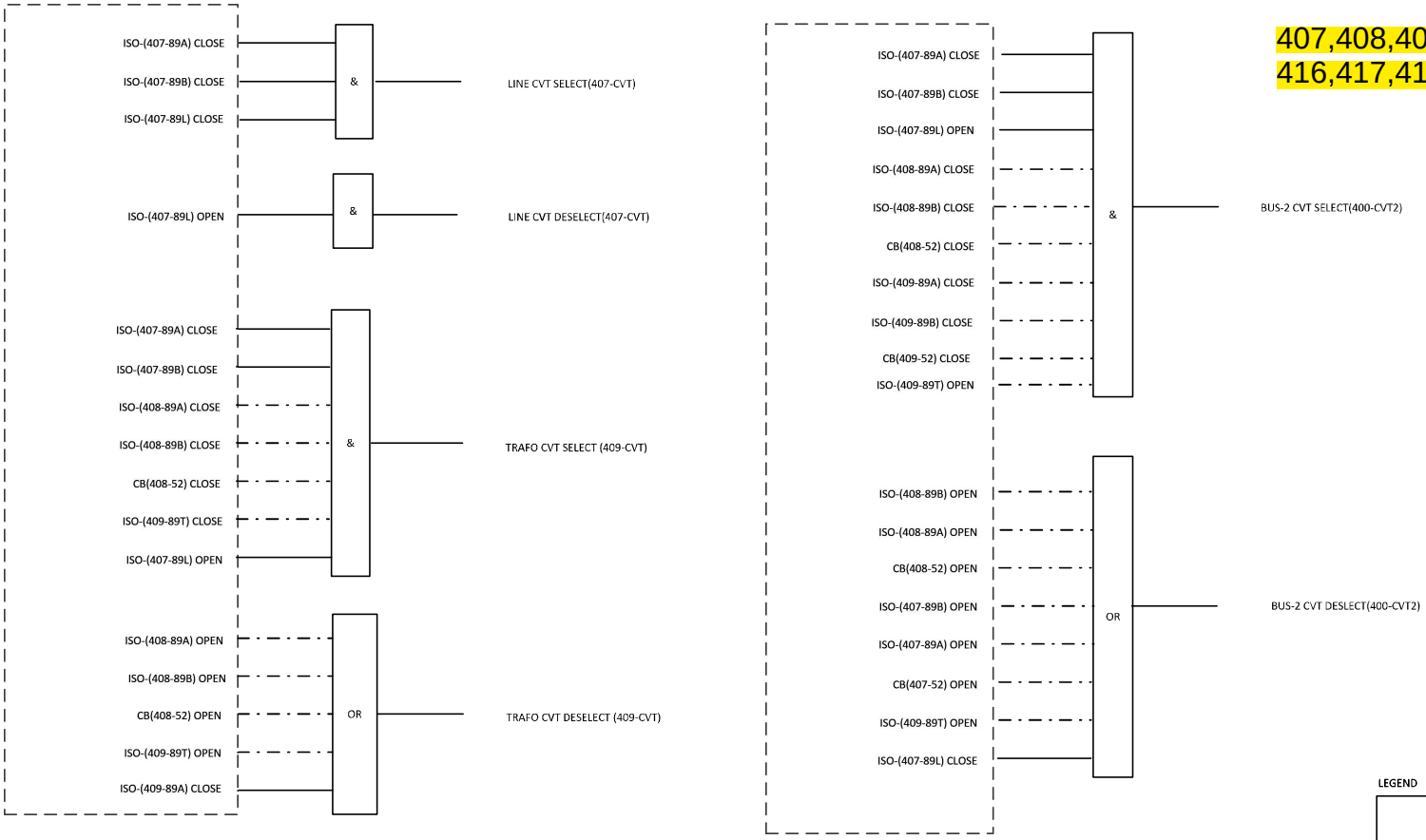
REFER DWG : Earthing accessories drawings – Clamps Joints & Cleats

400kV/230kV MEGHNAGHAT SUBSTAION
POWER GRID COMPANY OF BANGLADESH LTD.

TITLE:	DRAWING NO.:	SHEET No.	REV.
TYPICAL EARTHING DETAILS FOR 33kV CABLE TERMINATION UNIT		32	4

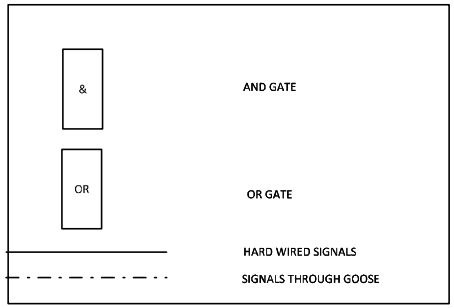
SHEET SIZE : A4 (210 x 297)

LINE BAY VT SELECTION

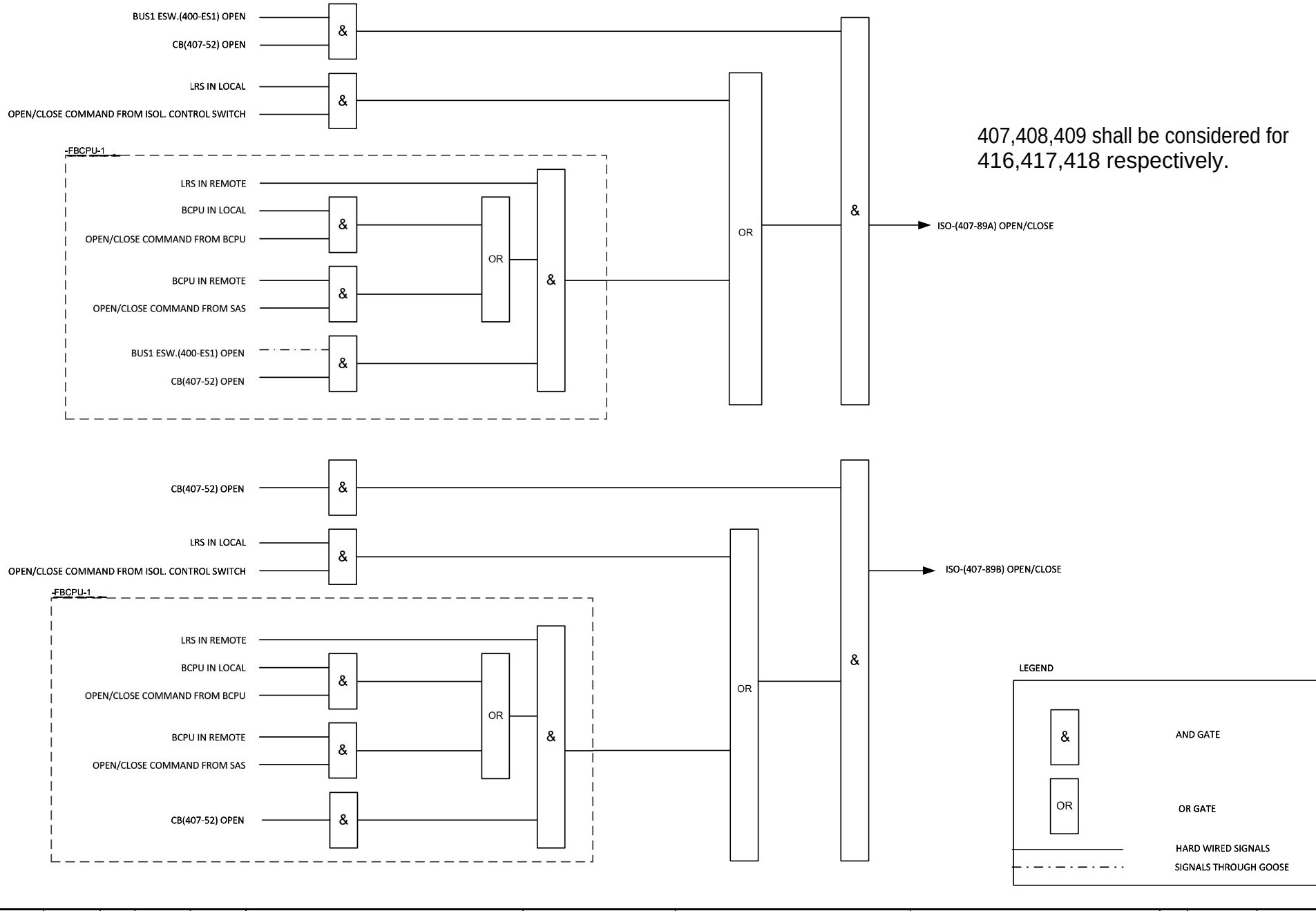


407,408,409 shall be considered for 416,417,418 respectively.

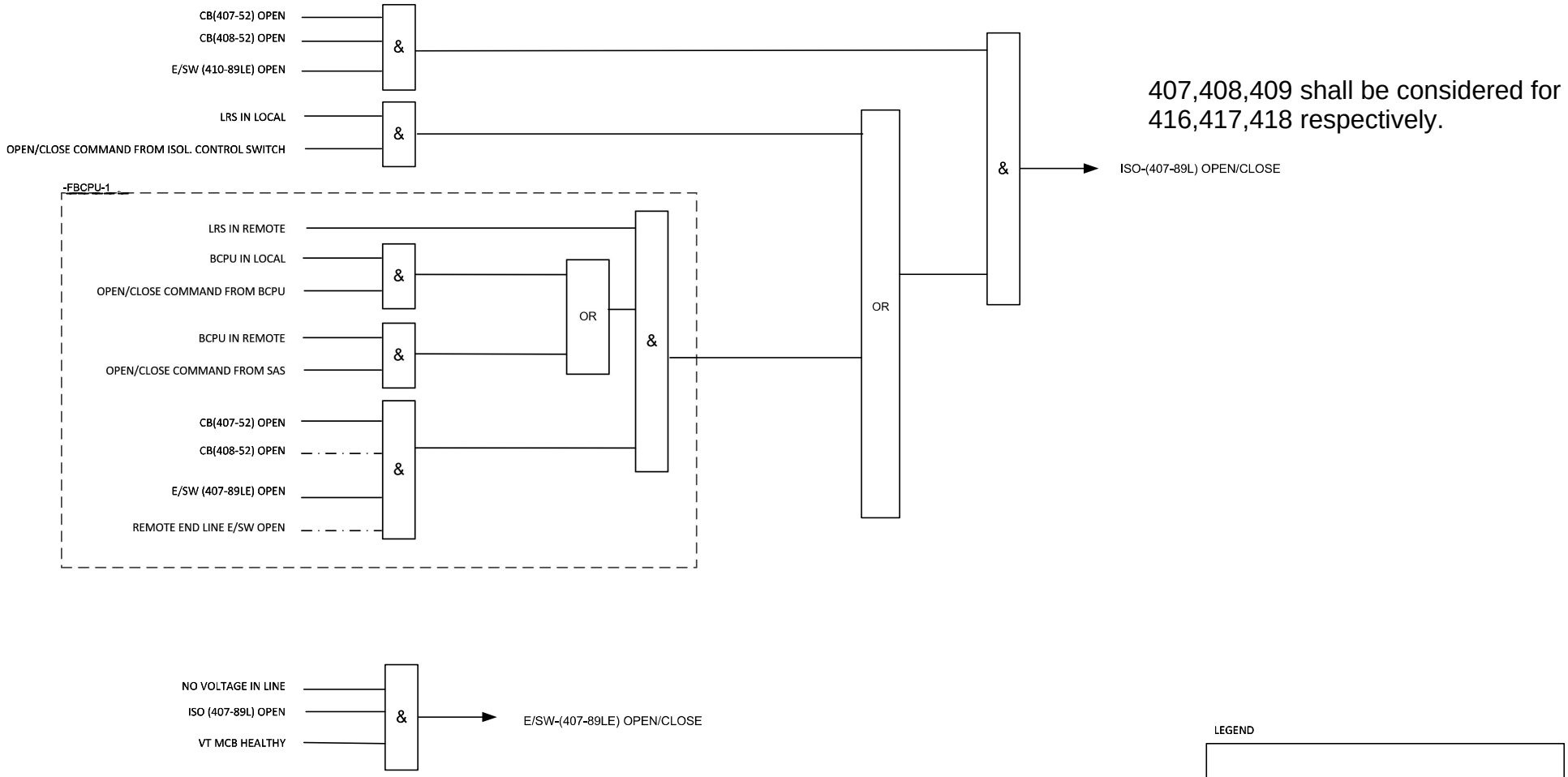
LEGEND



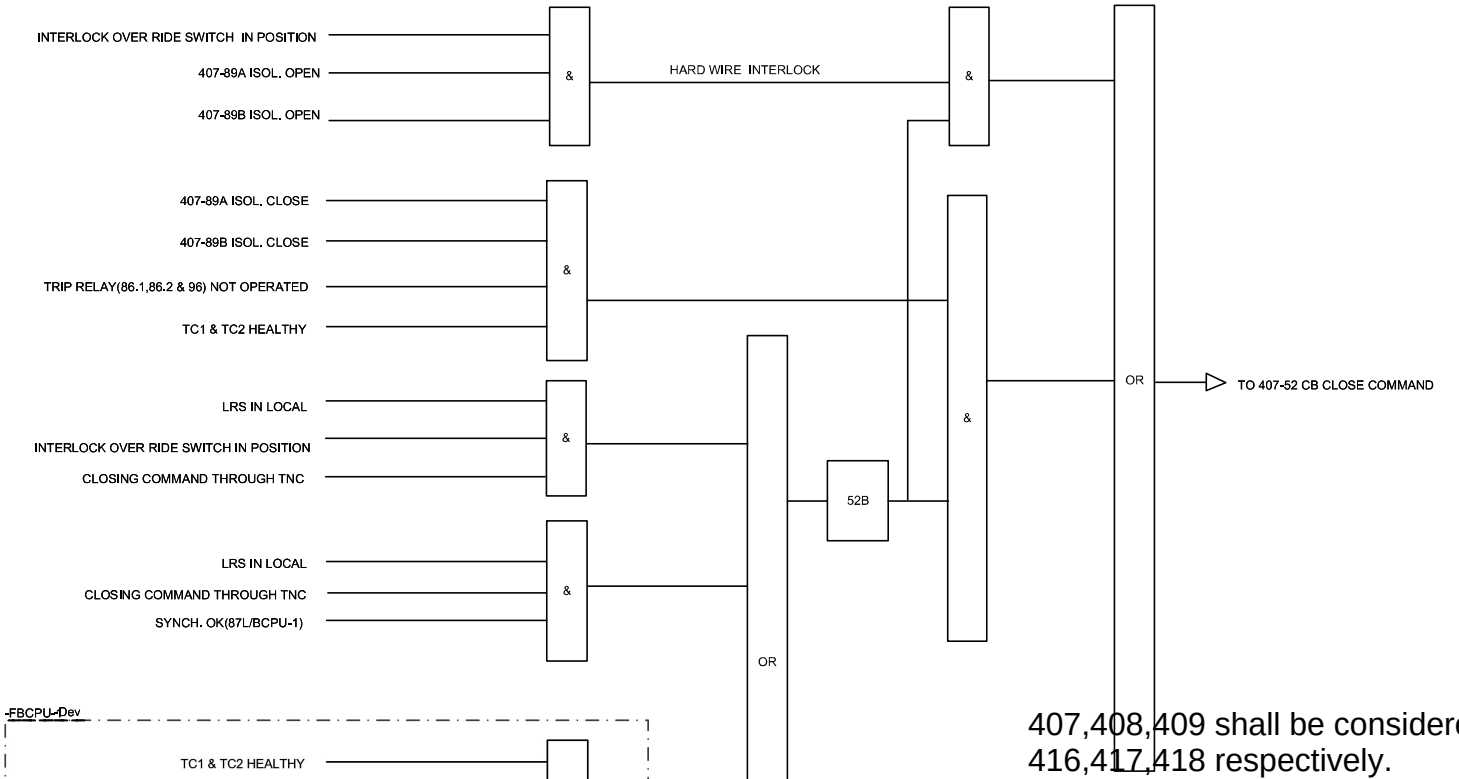
pp y	Orig.:	Replaces:	Replaced by:	400kV CONTROL & TIE PANEL (DIA-6 VT DISTRIBUTION CIRCUIT LOGIC	400/230kV MEGHNAGHAT AIS SUBSTATION CP1

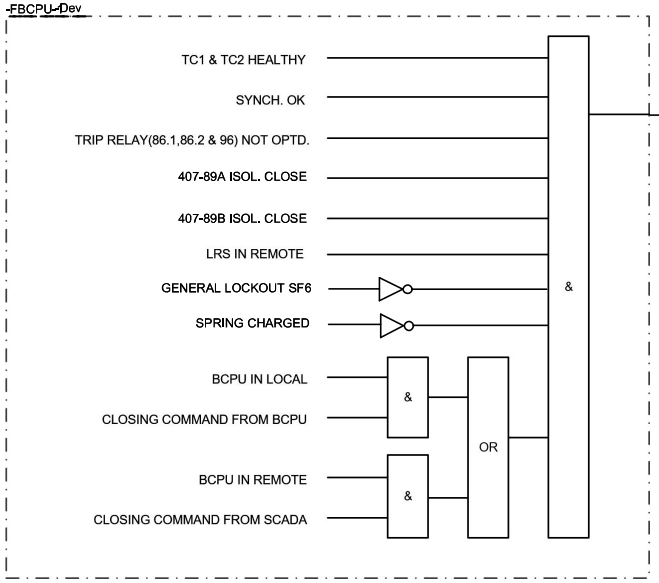


Replaced by:	400kV CONTROL & TIE PANEL (DIA-6 ISOLATOR I/L LOGIC (BAY-407)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1

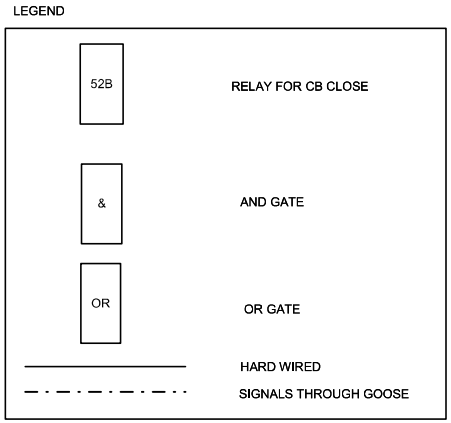


400kV CONTROL & TIE PANEL (DIA-6) ISOLATOR & ESW I/L LOGIC (BAY-407)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1



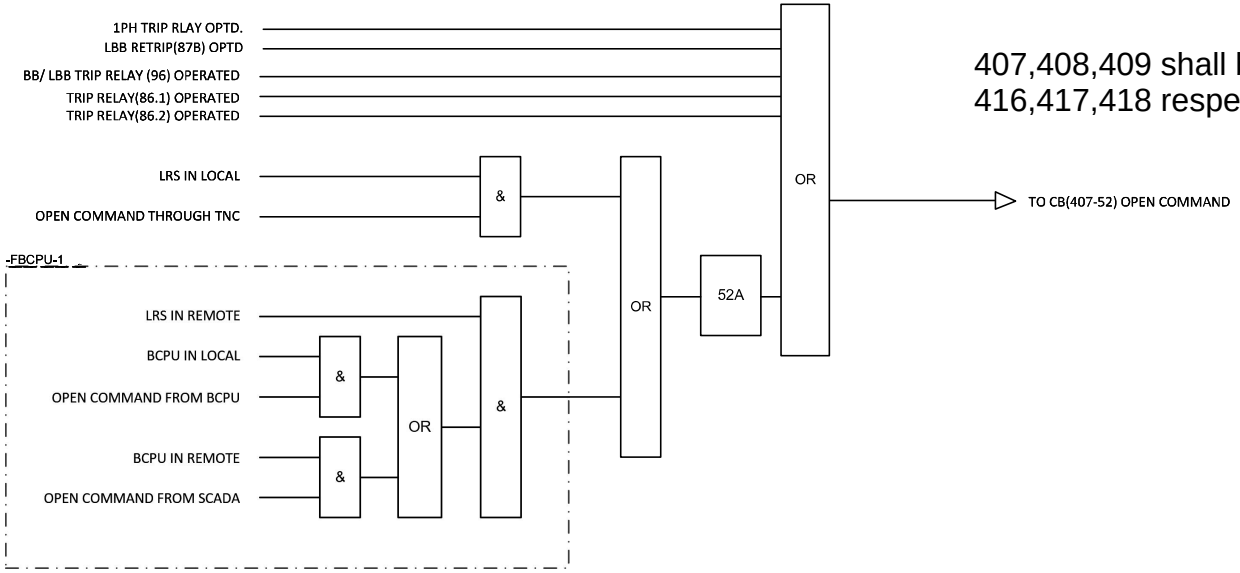


407,408,409 shall be considered for 416,417,418 respectively.



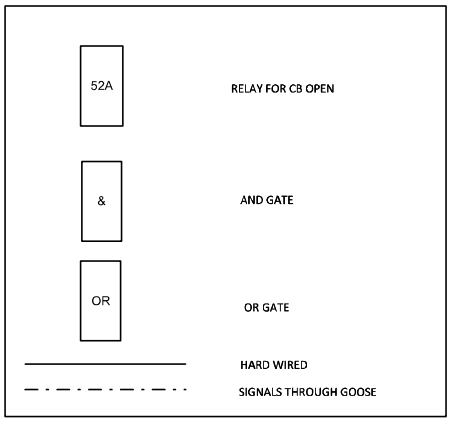
400kV CONTROL & TIE PANEL (DIA-6)		CP1
CB CLOSING LOGIC (BAY-407)	400/230kV MEGHNAGHAT AIS SUBSTATION	

R

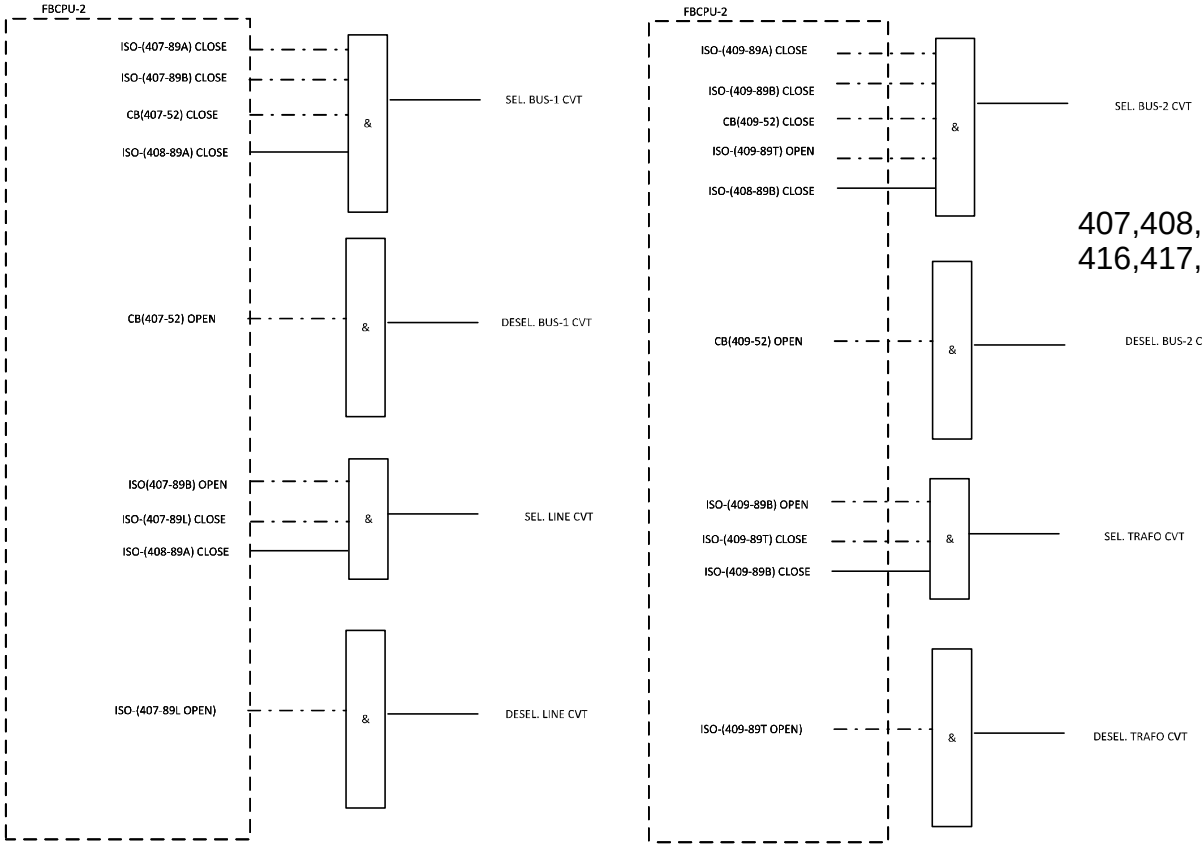


407,408,409 shall be considered for 416,417,418 respectively.

LEGEND



400kV CONTROL & TIE PANEL (DIA-6 CB OPENING LOGIC (BAY-407)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1



407,408,409 shall be considered for 416,417,418 respectively.

LEGEND

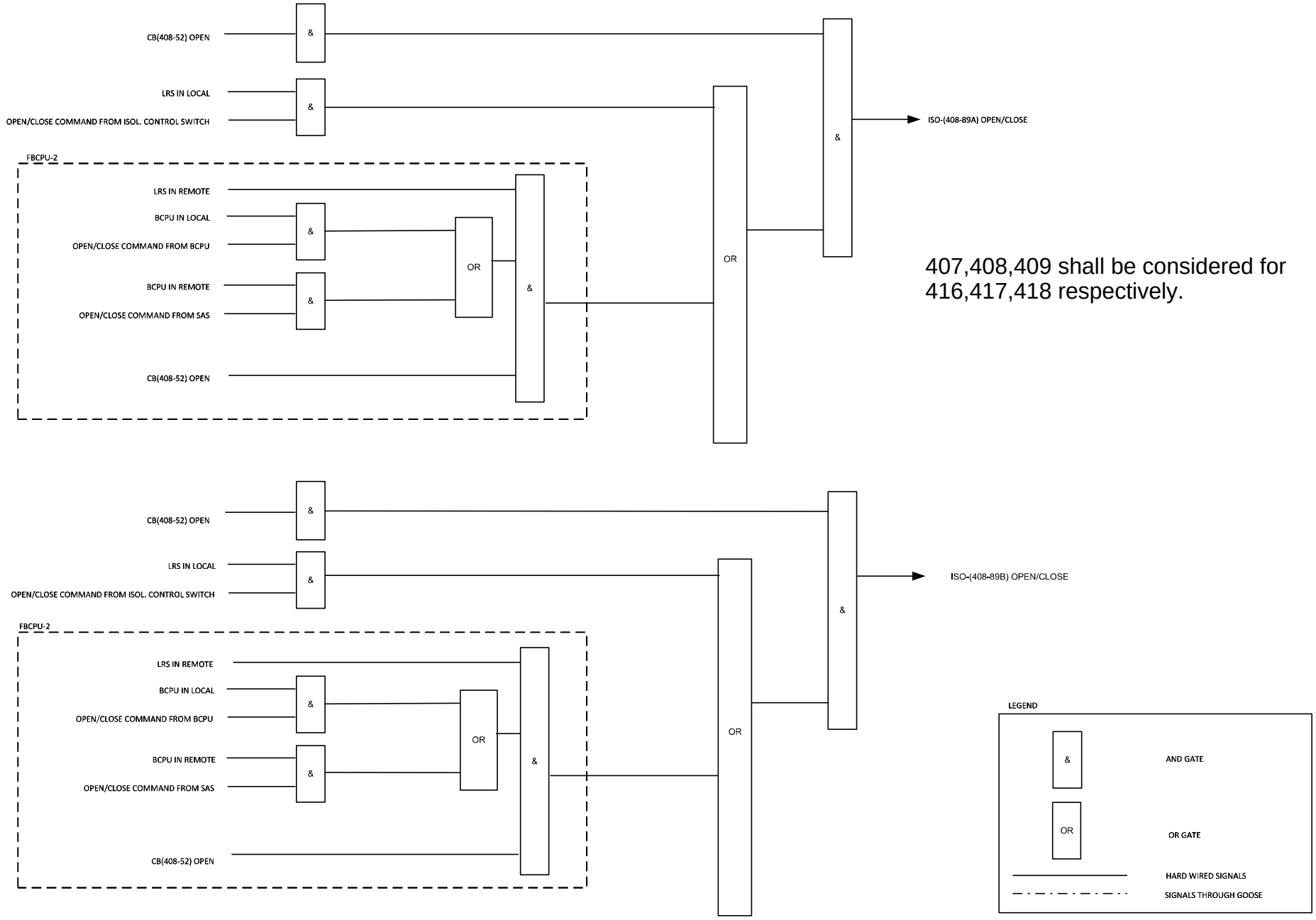
& AND GATE

OR OR GATE

HARD WIRED SIGNALS

SIGNALS THROUGH GOOSE

400kV CONTROL & TIE PANEL (DIA-6) VT DISTRIBUTION CIRCUIT LOGIC	400/230kV MEGHNAGHAT AIS SUBSTATION		408CP1

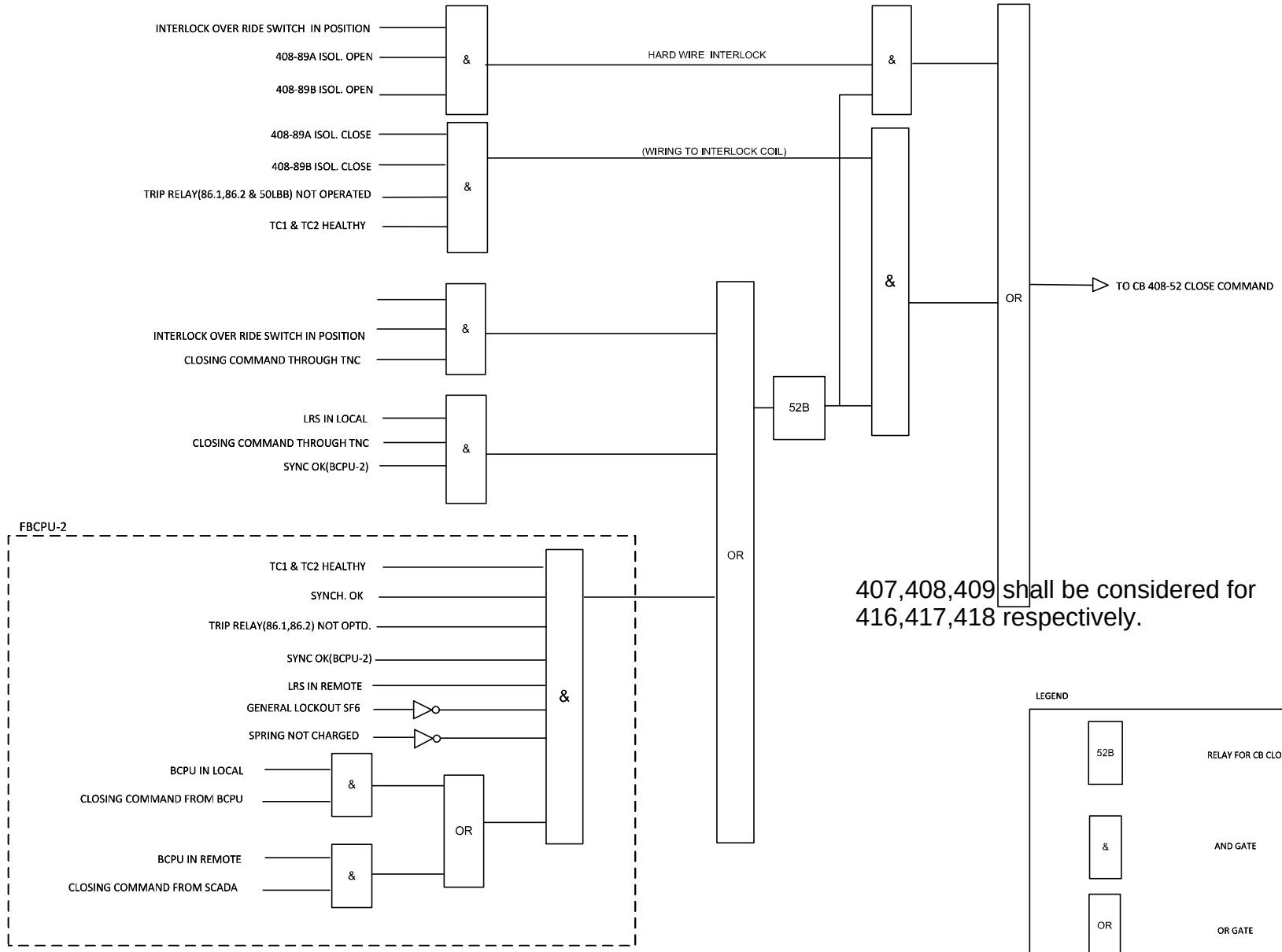


400kV CONTROL & TIE PANEL (DIA-6)
ISOLATOR I/L LOGIC (BAY-408)

400/230kV MEGHNAGHAT AIS SUBSTATION

CP1

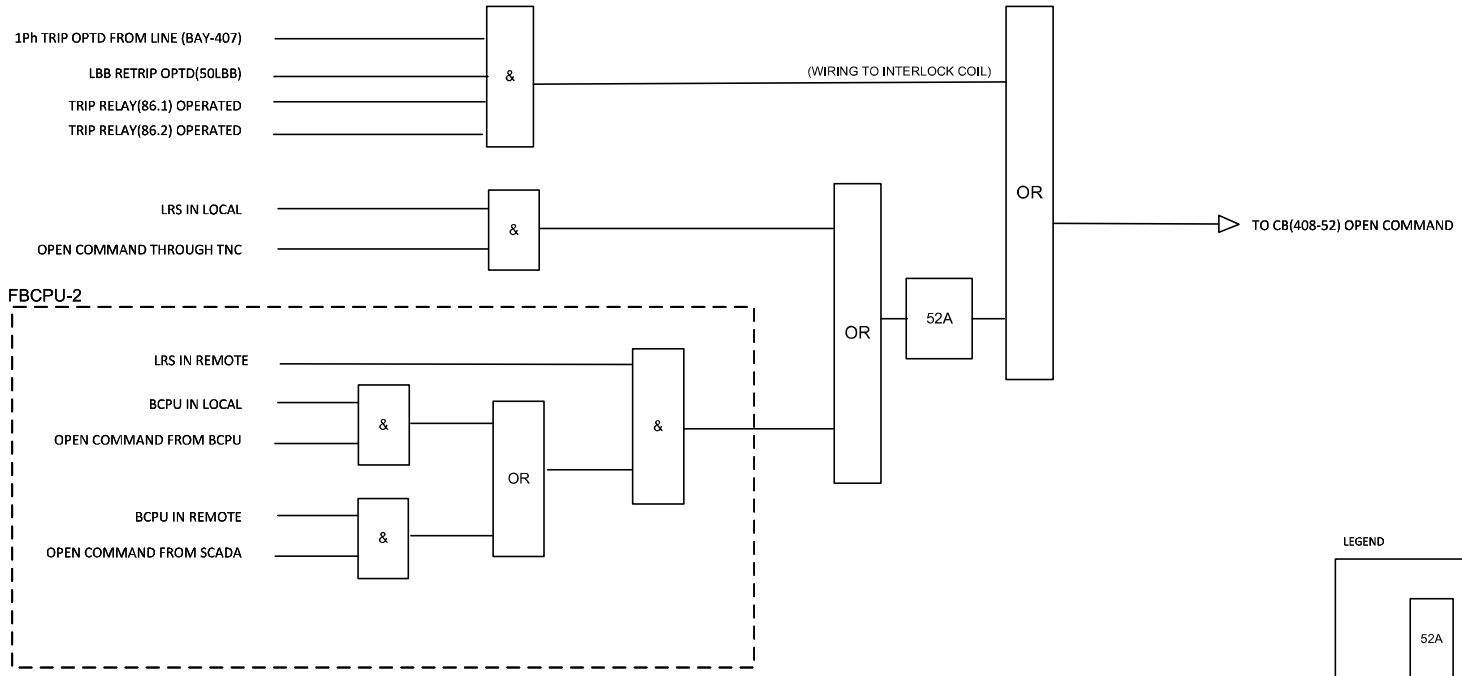
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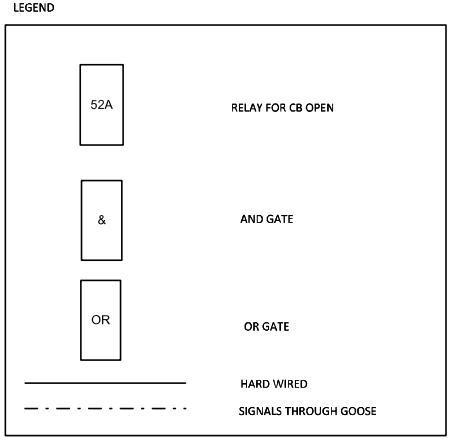


407,408,409 shall be considered for 416,417,418 respectively.

400kV CONTROL & TIE PANEL (DIA-C) CB CLOSING LOGIC (BAY-408)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1

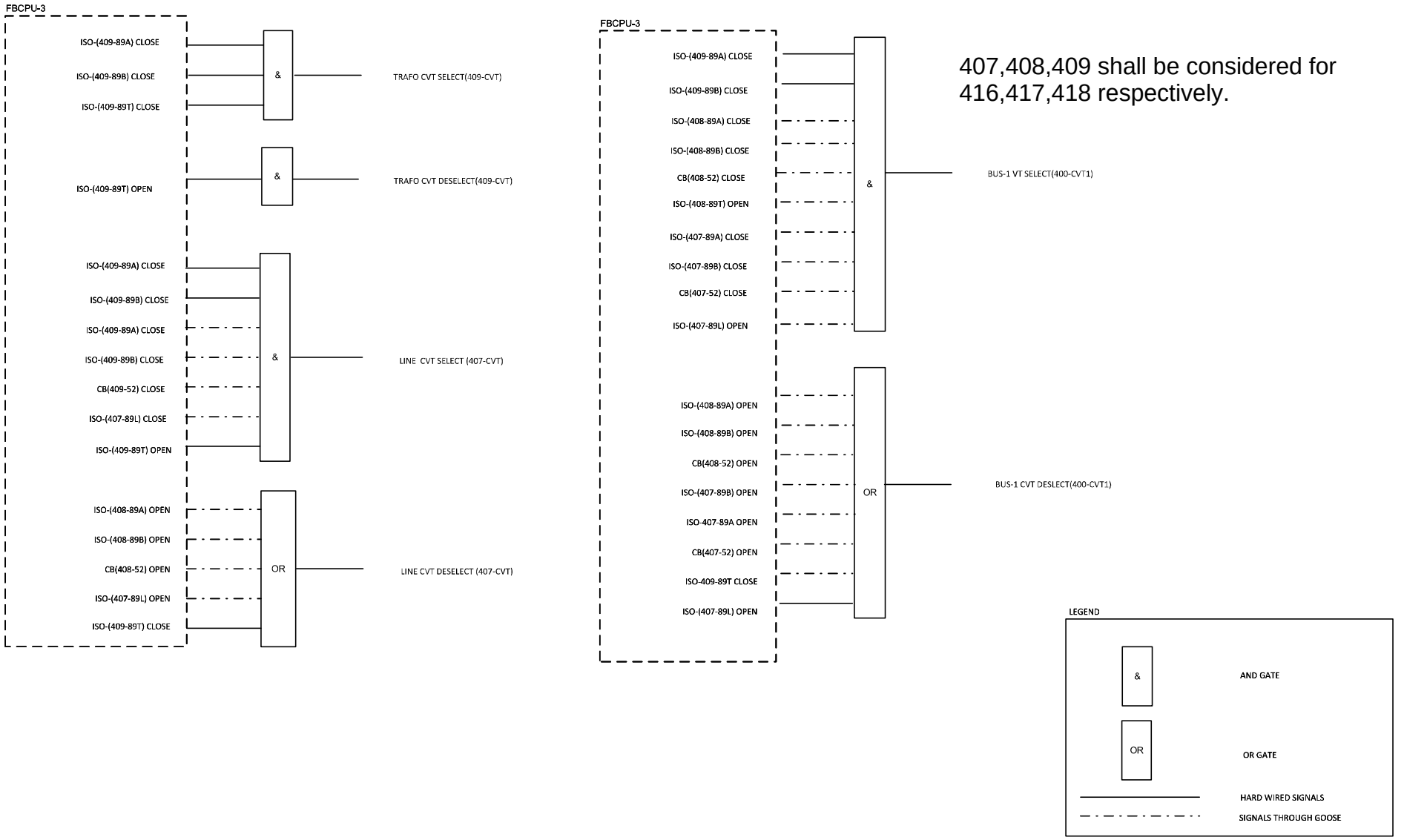
407,408,409 shall be considered for 416,417,418 respectively.





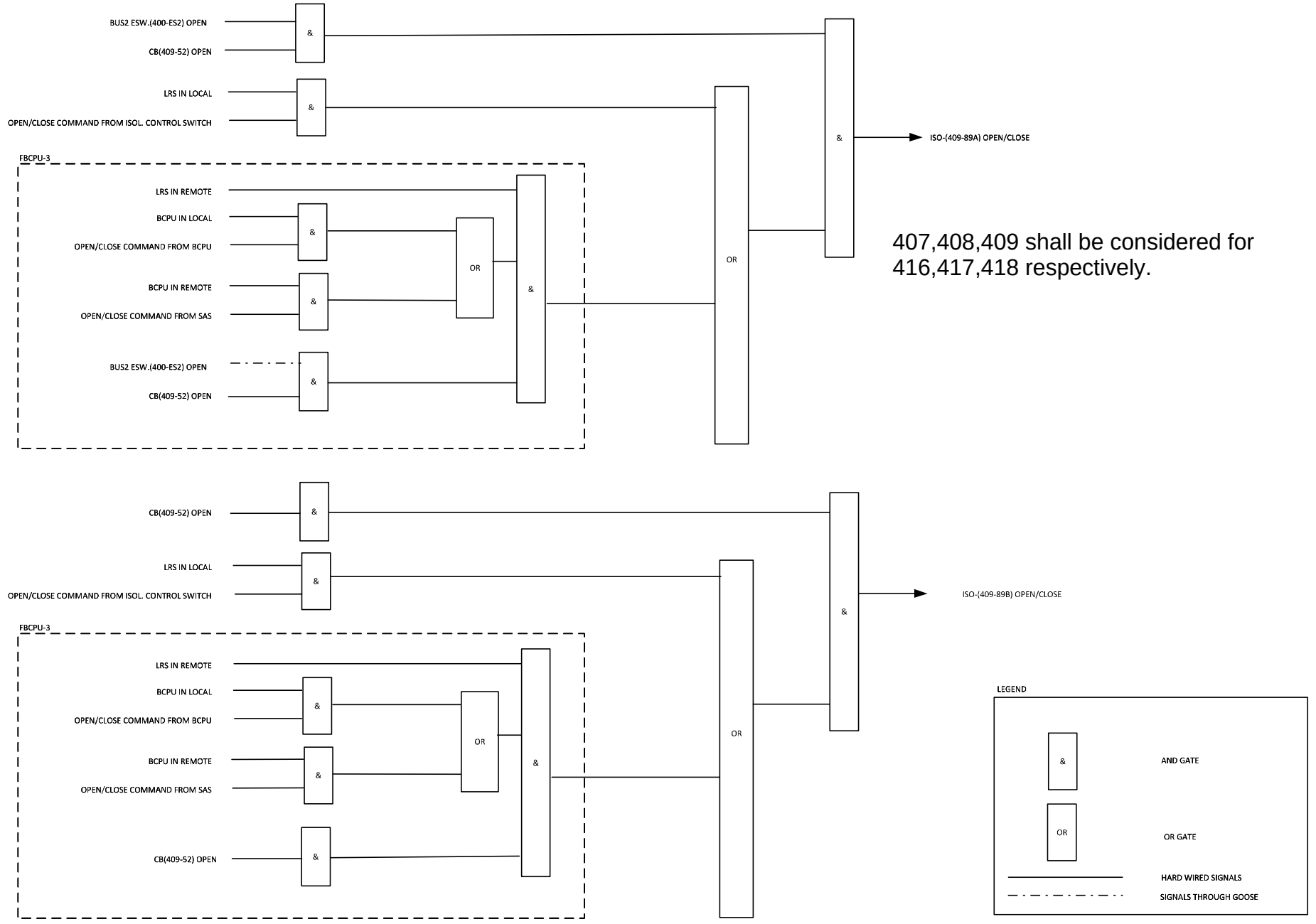
R	400kV CONTROL & TIE PANEL (DIA-6) CB OPENING LOGIC (BAY-408)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1

TRAFO BAY VT SELECTION



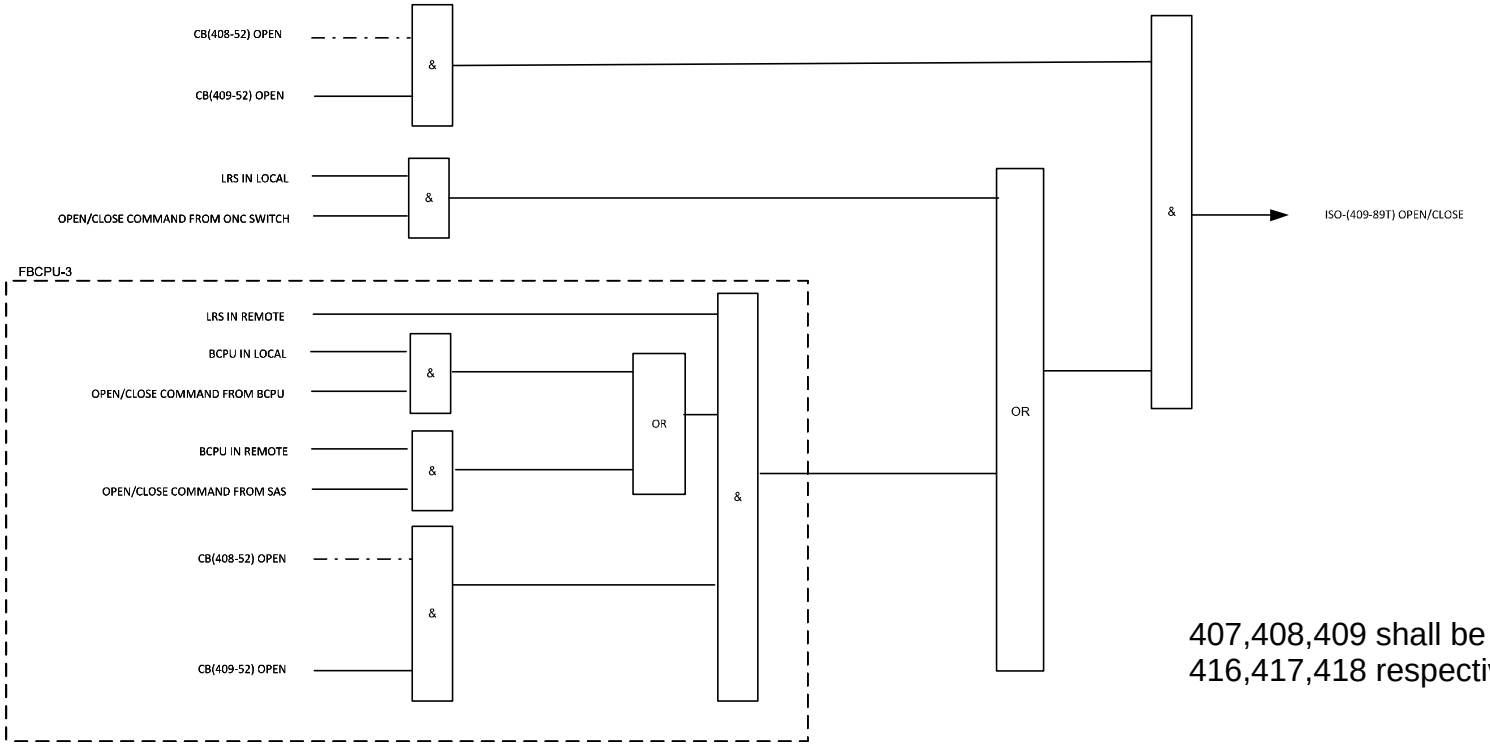
407,408,409 shall be considered for 416,417,418 respectively.

400kV CONTROL & TIE PANEL (DIA-6 VT DISTRIBUTION CIRCUIT LOGIC	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1



400kV CONTROL & TIE PANEL (DIA-6) ISOLATOR CONTROL CIRCUIT (BAY-409)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1

R



407,408,409 shall be considered for 416,417,418 respectively.

LEGEND

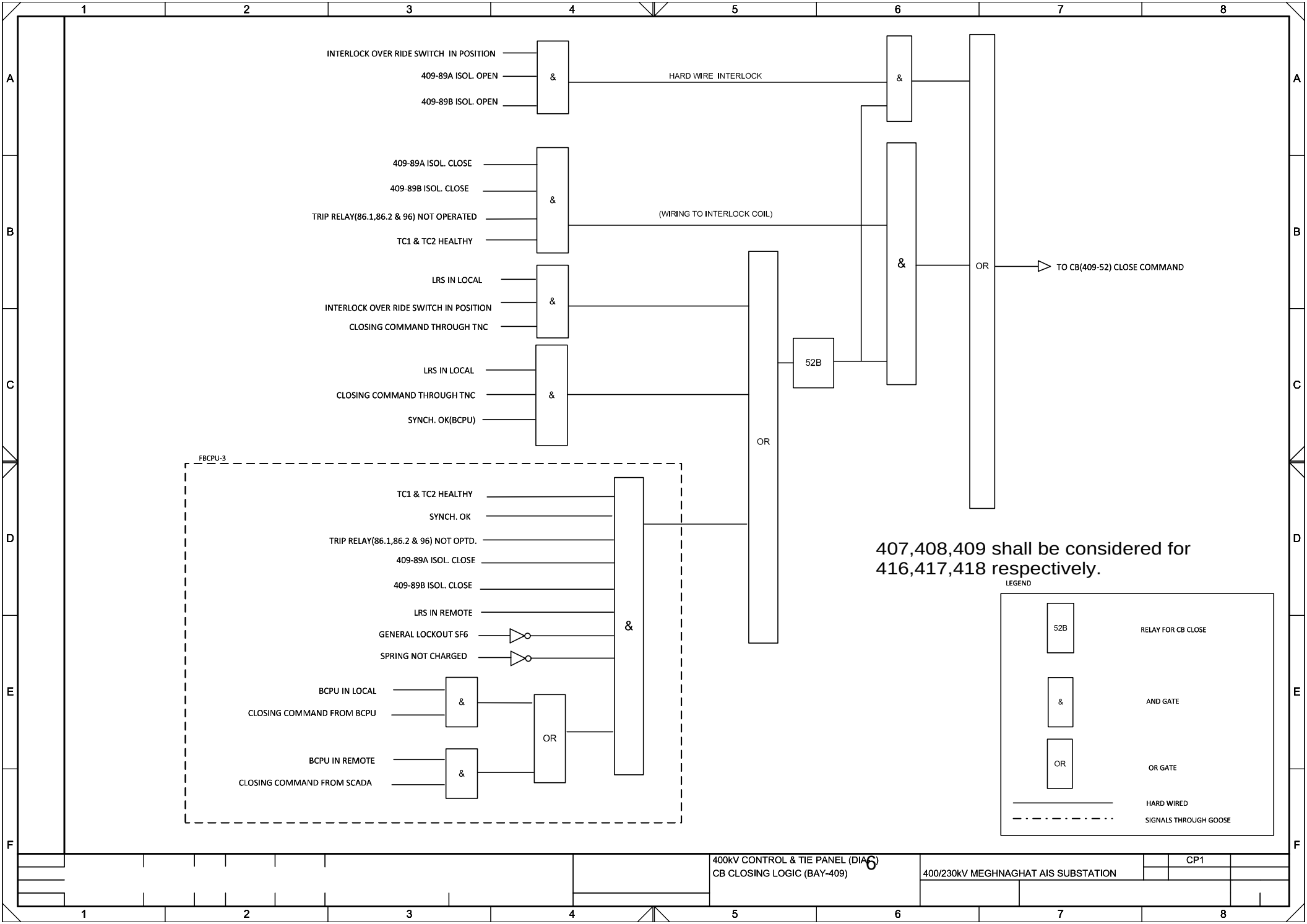
& AND GATE

OR OR GATE

HARD WIRED SIGNALS

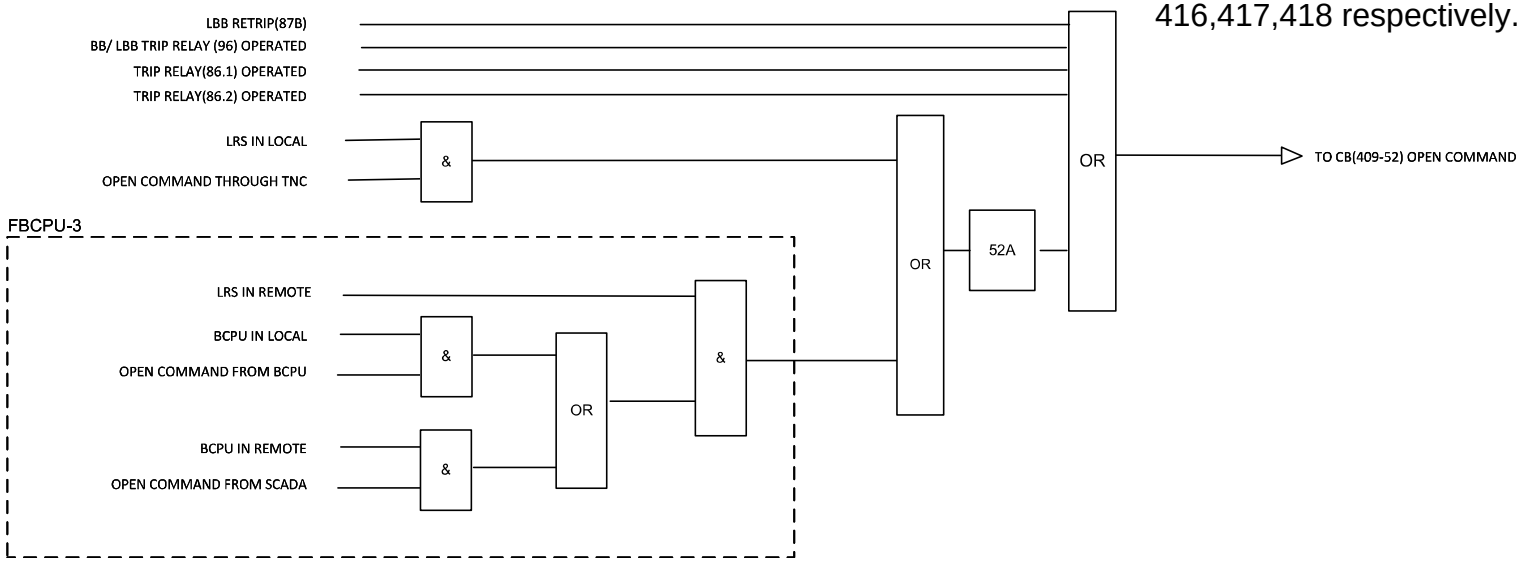
SIGNALS THROUGH GOOSE

	400kV CONTROL & TIE PANEL (DIA-6) ISOLATOR CONTROL CIRCUIT (BAY-409)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1

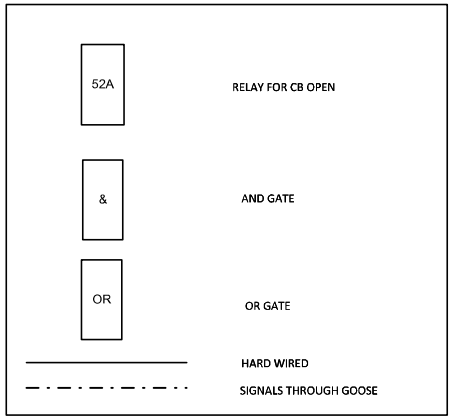


400kV CONTROL & TIE PANEL (DIA-6) CB CLOSING LOGIC (BAY-409)	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1

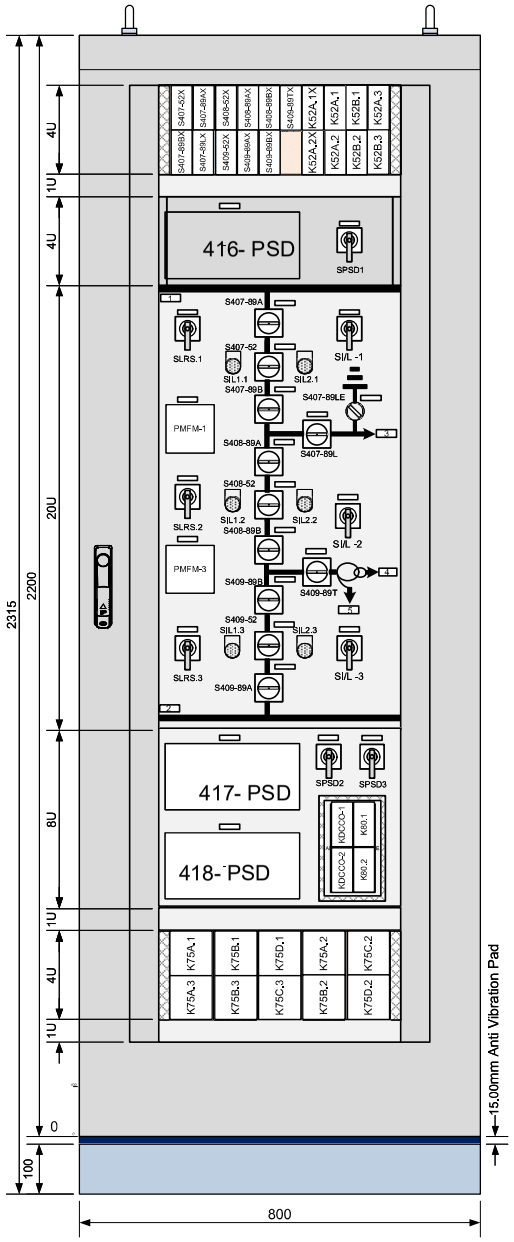
407,408,409 shall be considered for 416,417,418 respectively.



LEGEND



400kV CONTROL & TIE PANEL (DIA-6	400/230kV MEGHNAGHAT AIS SUBSTATION	CP1
CB OPENING LOGIC(BAY-409)		

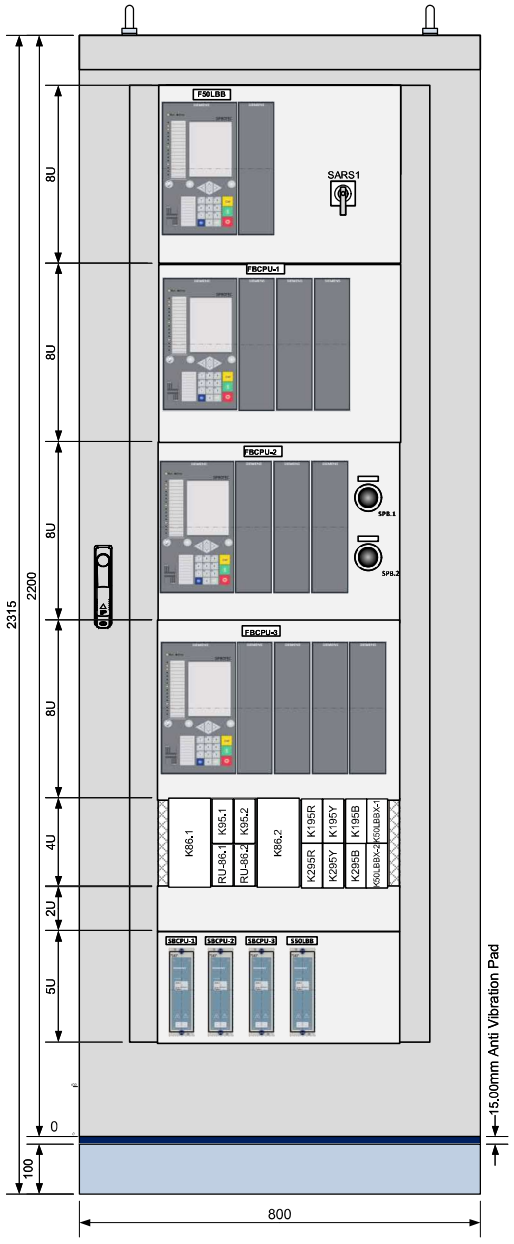


Type	Qty.	Name Plate Description
A (Board)	1	400kV CONTROL & TIE PANEL (DIA- 6) CP1

MIMIC NAME PLATE :
1.400kV BUS-1
2.400kV BUS-2
3 line
4
5.ICT- 3

Dimension Unit: mm, All Dimension Tolerance= ±5mm

400kV CONTROL & TIE PANEL (DIA-6) FRONT VIEW General Arrangement	Customer Dwg No. P2	CP1	1 mm. : 10 mm.
	400/230kV MEGHNAGHAT AIS SUBSTATION		



Type	Qty.	Name Plate Description
A (Board)	1	400kV CONTROL & TIE PANEL (DIA-6) CP2

Dimension Unit: mm, All Dimension Tolerance= ±5mm

400kV CONTROL & TIE PANEL (DIA-6	Customer Dwg No. P2	CP2 | 1 mm. : 10 mm.
FRONT VIEW	400/230kV MEGHNAGHAT AIS SUBSTATION	
General Arrangement		

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Date: 12/12/2021
Time: 7:41:31 PM
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400/230kV MEGHNAGHAT SUBSTATION 400kV BUSBAR PROTECTION 400 20

400BB

FMCU1

LMZ1-2

F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400kV MADUNAGHAT-1 RELAY PANEL(401-RA)	BU1 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400kV MADUNAGHAT-2 RELAY PANEL(404-RA)	BU2 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400kV UNIQUE PP LINE RELAY PANEL(407)	BU3 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400/230/33kV AUTO TRANSFORMER-1 RELAY PANEL(409)	BU4 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400kV AMINBAZAR-1 RELAY PANEL(410)	BU5 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400/230/33kV AUTO TRANSFORMER-2 RELAY PANEL(412)	BU6 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
F87B1 RELAY FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR 400kV AMINBAZAR-2 RELAY PANEL(413)	BU7 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU8 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU9 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR

FMCU1

LMZ1-2

Future FUTURE USE	BU10 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU11 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU12 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU13 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU14 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU15 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR
Future FUTURE USE	BU16 Tx	FIBRE OPTIC INTERFACE 820mm, ST CONNECTOR

DESIGN,SUPPLY,ERECTION,TESTING & COMMISSIONING
OF 400/230kV Meghnaghat A`S SUBSTATION
CONTRACT NO.:PGCB/DCMPGSP/BD-P81/S-701 DATED: 23.05.2[illegible]
APPROVED
Approval, with or without modification of the document shall not relieve the Contractor of any responsibility of liability, as per GC 20.3.6
DATE: 15 FEB 2022
K. WAKAMATSU
Project Manager of [illegible] JV TEPSCG & NK

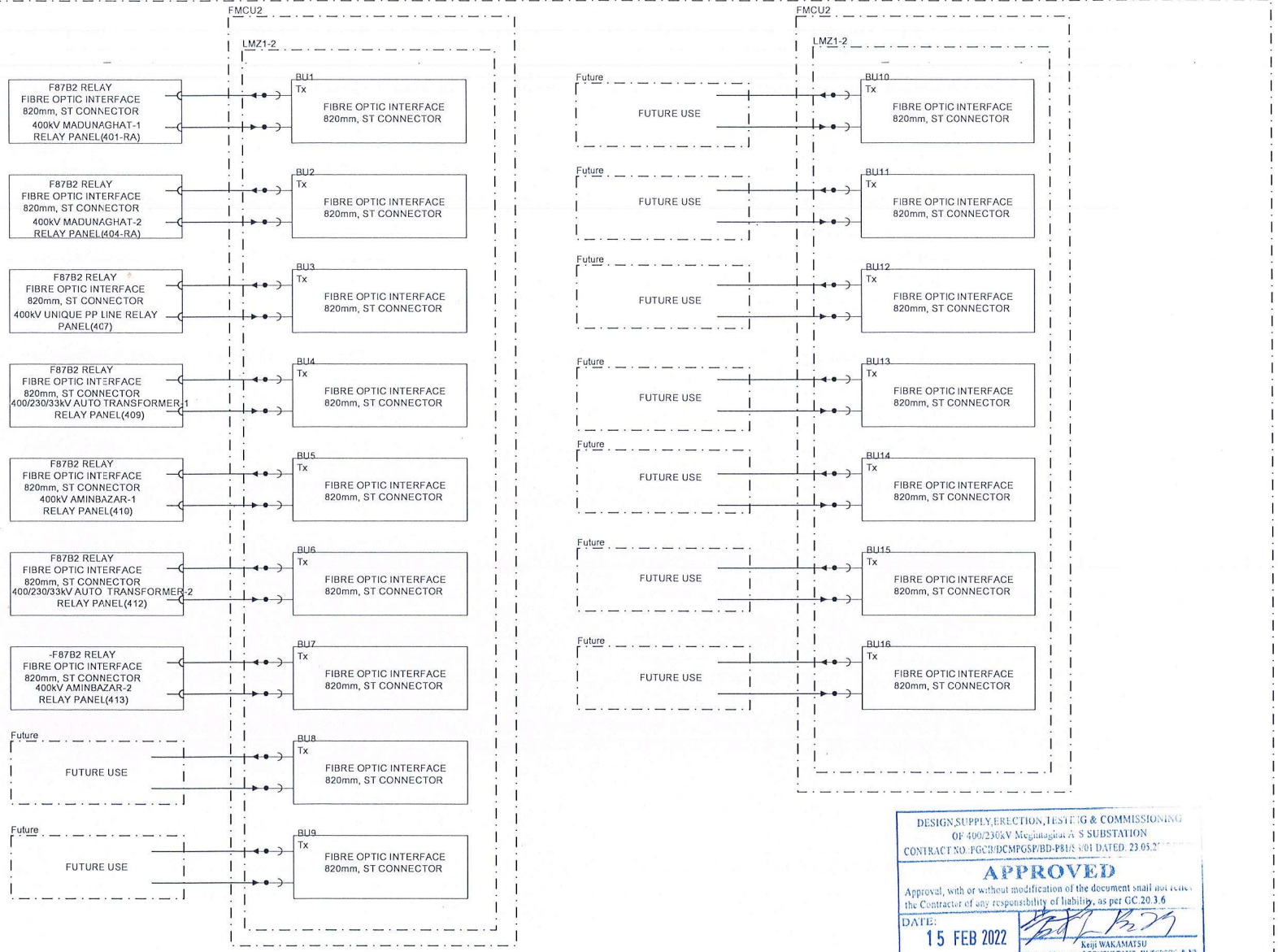
NOTE: FO PORT ASSIGNED FOR UNIQUE PP BAY WHICH IS NOT IN SCOPE OF THIS PACKAGE

F	Rev. Submission	01/13/2022	SATIS	Version	6	400/230kV MEGHNAGHAT SUBSTATION	SIEMENS	400kV BUSBAR PROTECTION		400BB	
E	Rev. Submission	12/10/2021	SATIS	Drawn By	RAMA	POWER GRID COMPANY OF BANGLADESH LIMITED		BUSBAR CONFIGURATION DIAGRAM (FMCU1)	400/230kV MEGHNAGHAT AIS SUBSTATION		
D	Rev. Submission	10/22/2021	SATIS	Chkd By	RANJAN	CONSORTIUM OF SIEMENS LTD & SIEMENS AG		External Connections	3006333453	(4)-G719EA-MG9063-00-400	Sh. 20 of 45
Revision	Remarks	Date	Name	Appr By	GEHM	Orig.:	Replaces:	Replaced by:			<19|21>

E-Base Version: 6.9.1.1232
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400/230kV MEGHNAGHAT SUBSTATION 400kV BUSBAR PROTECTION 400 24

400BB



DESIGN,SUPPLY,ERECTION,TESTING & COMMISSIONING OF 400/230kV Meghnaghat A S SUBSTATION
CONTRACT NO. PGCB/DCMPQSP/BD-P81/S-01 DATED. 23.05.2[illegible]

APPROVED

Approval, with or without modification of the document shall not relieve the Contractor of any responsibility of liability, as per GC 20.3.6

DATE: 15 FEB 2022

Keiji WAKAMATSU
Project Manager of CONSULTANT, JV TEPSCO & NS

NOTE: FO PORT ASSIGNED FOR UNIQUE PP BAY WHICH IS NOT IN SCOPE OF THIS PACKAGE

Revision	Remarks	Date	Name	Appr By
F	Rev. Submission	01/13/2022	SATIS	Version 6
E	Rev. Submission	12/10/2021	SATIS	Drawn By RAMA
D	Rev. Submission	10/22/2021	SATIS	Chkd By RANJAN
				GEHM

400/230kV MEGHNAGHAT SUBSTATION
POWER GRID COMPANY OF BANGLADESH LIMITED
CONSORTIUM OF SIEMENS LTD & SIEMENS AG
Orig.: Replaces:

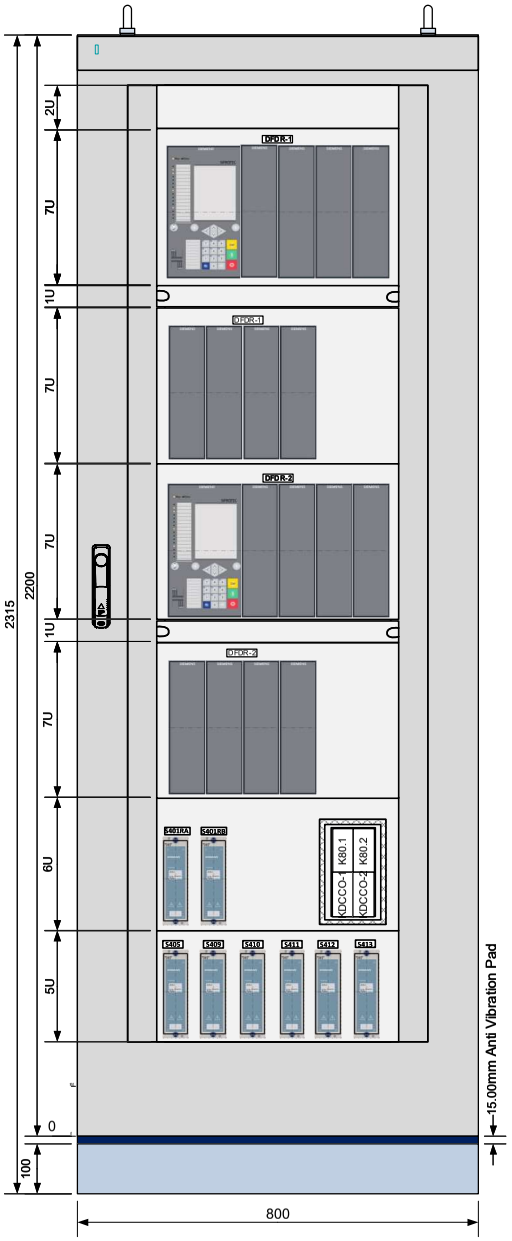
SIEMENS
Replaced by:

400kV BUSBAR PROTECTION
BUSBAR CONFIGURATION DIAGRAM (FMCU2)
External Connections

400/230kV MEGHNAGHAT AIS SUBSTATION
3006333453
(4)-G719EA-MG9063-00-400

400BB

Sh. 24 of 45
<23|25>

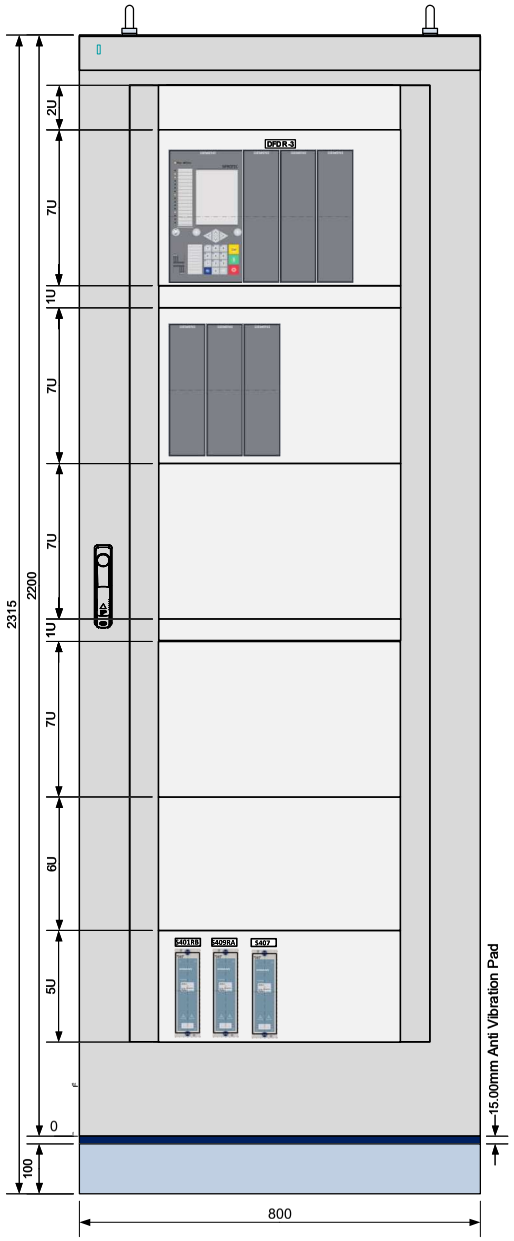


Type	Qty.	Name Plate Description
A (Board)	1	400kV DFDR PANEL-1 PANEL REF-FR400RA

S. NO.	▲2 DESIGN.	DESCRIPTION	TYPE	MANUFACTUR...
1	ABB Case	RHGX4-With Case (Flush)	RHGX	ABB
2	DFDR-1	Fault Recorder	7KE85	Siemens
3	DFDR-2	Fault Recorder	7KE85	Siemens
4	K80.1	DC-1 Supervision Relay	TSR-B	ABB
5	K80.2	DC-2 Supervision Relay	TSR-B	ABB
6	KDCCO-1	DC-1 Change Over Relay	RXME1	ABB
7	KDCCO-2	DC-2 Change Over Relay	RXME1	ABB
8	S401RA	Relay test block	7XG22	Siemens
9	S401RB	Relay test block	7XG22	Siemens
10	S405	Relay test block	7XG22	Siemens
11	S409	Relay test block	7XG22	Siemens
12	S410	Relay test block	7XG22	Siemens
13	S411	Relay test block	7XG22	Siemens
14	S412	Relay test block	7XG22	Siemens
15	S413	Relay test block	7XG22	Siemens

Note: 1U = 44.45mm Dimension Unit: mm, All Dimension Tolerance= ±5mm

400KV DISTURBANCE FAULT RECORDER FRONT VIEW General Arragenment	400/230kV MEGHNAGHAT AIS SUBSTATION	FR400RA	1 mm. : 10 mm.
Revision			



Type	Qty.	Name Plate Description
A (Board)	1	400kV DFDR PANEL-2 PANEL REF-FR400RB

S. NO.	▲2 DESIGN.	DESCRIPTION	TYPE	MANUFACTURER
1	DFDR-3	Fault Recorder	7KE85	Siemens
2	S401RB	Relay test block For 401 Bay	7XG22	Siemens
3	S407	Relay test block For 407 Bay	7XG22	Siemens
4	S409RA	Relay test block	7XG22	Siemens

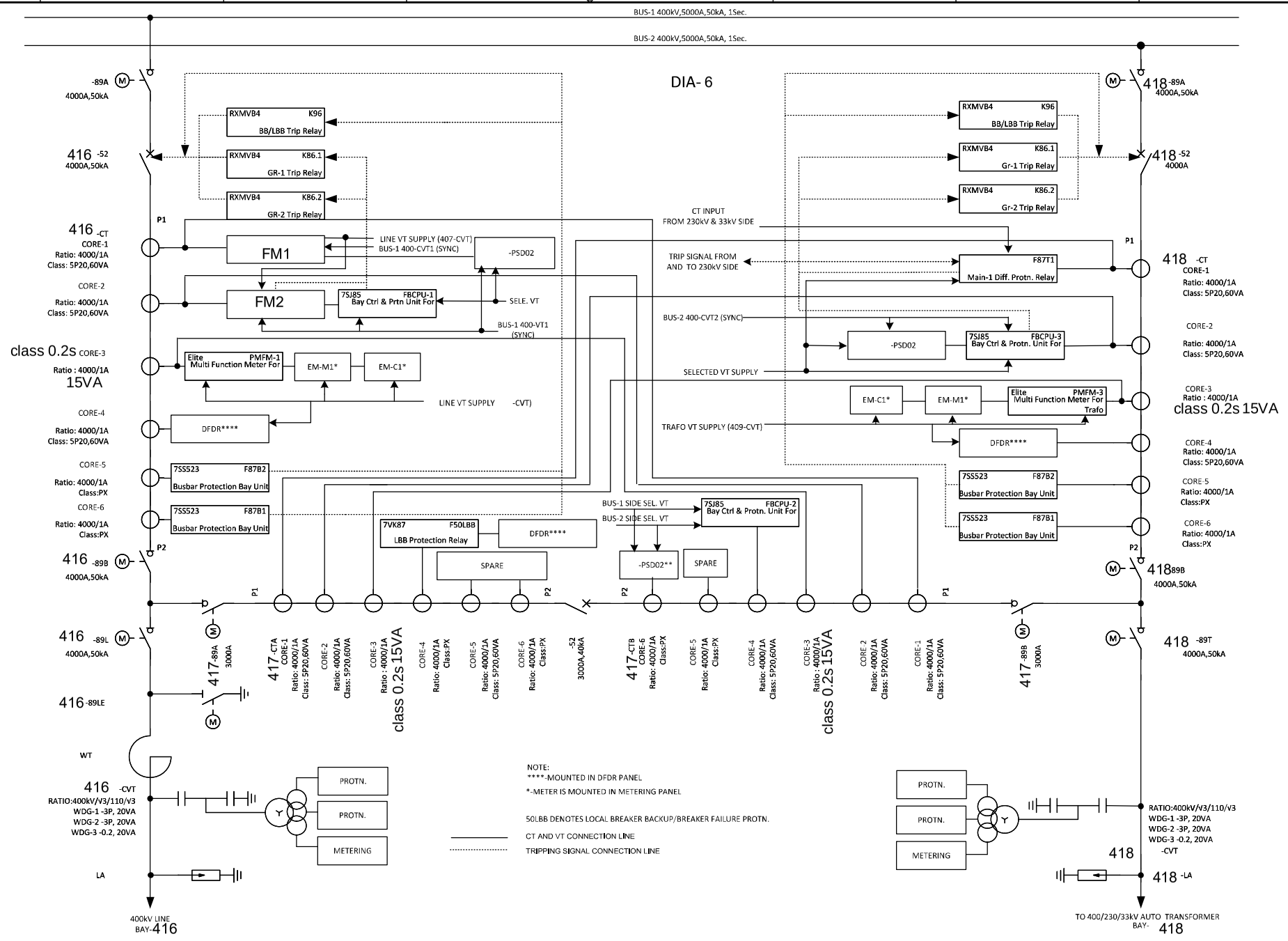
NEW DFDR CAN BE ACCOMODATE IN THIS PANEL

Note: 1U = 44.45mm Dimension Unit: mm, All Dimension Tolerance= ±5mm

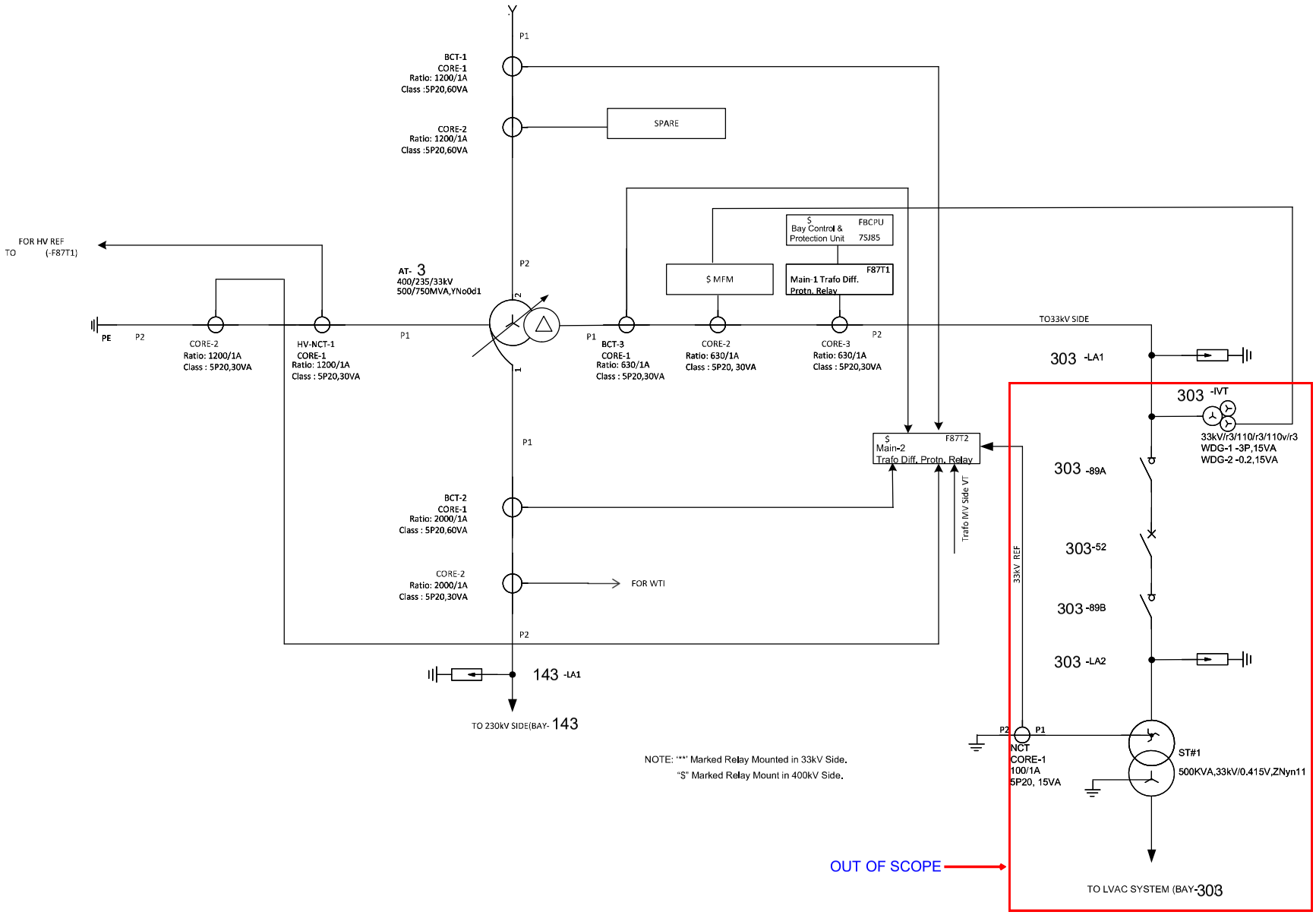
400KV DISTURBANCE FAULT RECORDER
FRONT VIEW
General Arragenment

400/230kV MEGHNAGHAT AIS SUBSTATION

FR400RB | 1 mm. : 10 mm.



400kV CONTROL & TIE PANEL (DIA-6) PROTECTION SLD		400/230kV MEGHNAGHAT AIS SUBSTATION



400kV CONTROL & TIE PANEL (DIA-6 PROTECTION SLD	400/230kV MEGHNAGHAT AIS SUBSTATION		408CP1	

TR SELF PROTECTION

TR MV LA

-BA1

0.2 3P 3P

EM (MAIN)	
EM (CHECK)	
MFM	
BCU (R,Y,B,N)	
DFDR (R,Y,B,N)	
BUFP (R,Y,B,N)	

	BCPU	
	67/67N (MV)	27
	51/51N (MV)	59
	50/50N (MV)	DDR
	25 (MV)	

143 CT-A

P2					
C5	CLASS: PX	BBP BU for future			
C4	CLASS: 0.2S	EM (MAIN)	EM (CHECK)	MFM	
C3	CLASS: 5P20	BCPU	7SJ85		
C2	CLASS: 5P20	DFDR			
C1	CLASS: 5P20	87T1			
P1					

CB GANG

143 CT-B

P2					
C5	CLASS: PX	BBP BU for future			
C4	CLASS: 0.2S	EM (MAIN)	EM (CHECK)	MFM	
C3	CLASS: 5P20	BCPU	7SJ85		
C2	CLASS: 5P20	M1FP			
C1	CLASS: 5P20	M2FP			
P1					

	M2FP	
	MAIN-2 FEEDER PROTECTION	
	87L	50/50N
	21	46BC
	21/85	50STUB
	67N/85	27
	SOTF	59
	68	79
	VTFF	79
	21FL	25
	67/67N	25
	51/51N	DDR

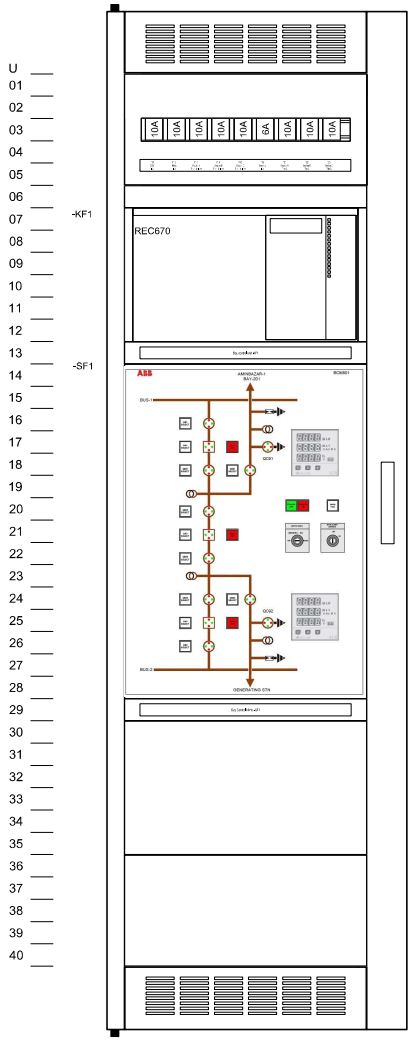
	M1FP	
	MAIN-1 FEEDER PROTECTION	
	87L	50/50N
	21	46BC
	21/85	50STUB
	67N/85	27
	SOTF	59
	68	79
	VTFF	79
	21FL	25
	67/67N	25
	51/51N	DDR

DSES

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+U Front view hinged frame

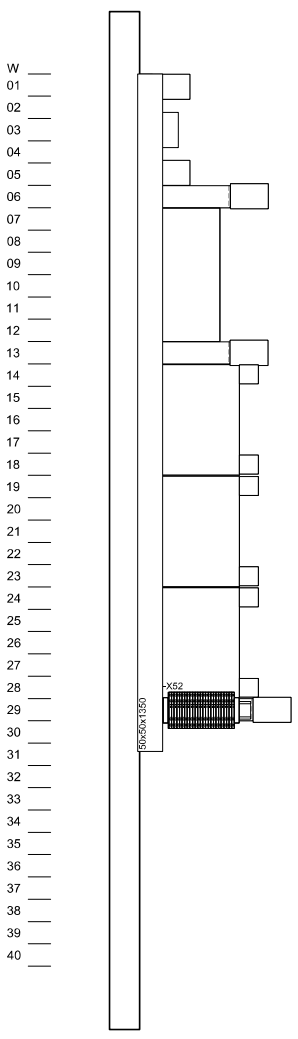
-UHKF1



-F11	10A	BCU & IO
-F12	10A	Mimic & IO
-F13	10A	Sec A Trip 1 & close
-F14	10A	Sec B Trip 1 & close
-F15	10A	Sec C Trip 1 & close
-F16	6A	Common IO
-F21	10A	Sect A Trip 2
-F22	10A	Sect B Trip 2
-F23	10A	Sect C Trip 2

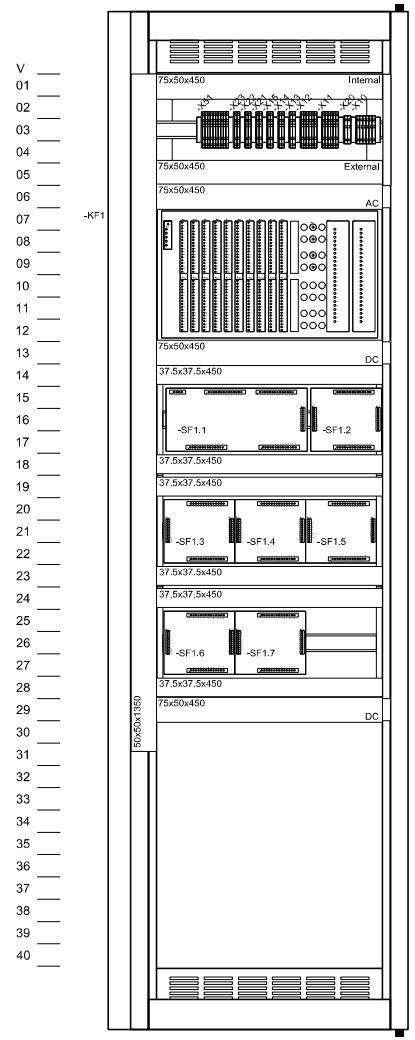
+W Side view hinged frame

-UHKF1



+V Back view hinged frame

-UHKF1



Rev.	Revision note	Date	Name
	AS BUILT 2015-01-14		

Based on 1KHF328874

Prepared

Approved

Project POWER GRID COMPANY OF BANGLADESH
230kV Meghnaghat Substation

Title 230kV Diameter -7
Cubicle layout
Hinged frame view

ABB Switzerland Ltd.

Doc. kind.

Ref.Des. =D1.Q07
+UHKF1

Resp. dept.

Rev. ind.

Language en

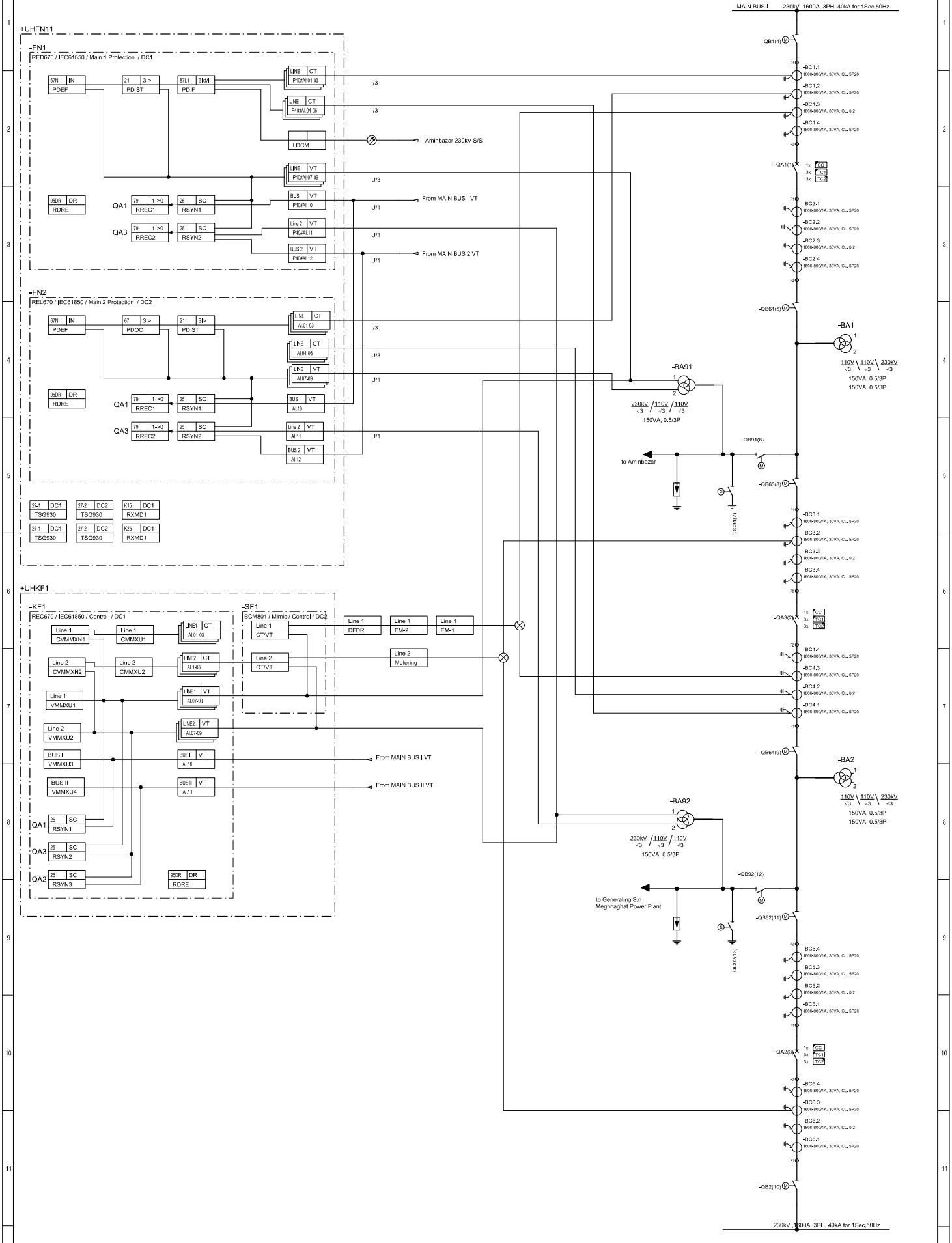
Doc. no. 1KHF335488

Sheet 13

n. sheet 14

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Based on 1KHF328874			Prepared	Title 230kV Diameter -7 Line to Aminbazar Block diagram	Doc. kind. Circuit diagram	Ref.Des.	=D1.Q07
AS BUILT 2015-01-14			Approved				
			Project POWER GRID COMPANY OF BANGLADESH 230kV Meghnaghat Substation 16304		Resp. dept.	Rev. ind.	Language
				ABB Switzerland Ltd.	Doc. no. 1KHF335488		Sheet 21
Rev.	Revision note	Date	Name				n. sheet 22

IED Type:	Protection Type:	Relay Code	Function Nr.	Step Nr.	ANSI	Function:	Comment	DC		HV Bus 1 CB (QA1)														HV Center CB (QA3)															HV BUS 2 CB (QA2)														COM CH1		COM CH2	
								Supplied		TC1			TC2			69	BCL	79		Start 50BF				TC1			TC2			69	BCL	79		Start 50BF					TC1			TC2			69	BCL	79		Start 50BF				SC	DTT	SC	DTT
							Comment	DC1	DC2	L1	L2	L3	L1	L2	L3	K15		AR	CC	L1	L2	L3	CB	L1	L2	L3	L1	L2	L3	K25		AR	CC	L1	L2	L3	L123	CB	L1	L2	L3	L1	L2	L3	K35		AR	CC	L1	L2	L3	CB	85	85	85	85
RED670 -FN1	RED670 V1.2			1		Device information line		x																																																
	Differential protection:	L6CPDIF	1	1	87L	line differential protection, 6 TC sets, 3-5 line ends				x	x	x						x		x	x	x		x	x	x						x		x	x	x																				
	Impedance protection:	ZMQPDIS	1	1	21	distance protection 3 zone, quadrilateral	Zone 1 Fw blocked if 87L is ok			x	x	x						x		x	x	x		x	x	x						x		x	x	x																				
	Impedance protection:	ZMQPDIS	2	1	21	distance protection 3 zone, quadrilateral	Zone 2 first Backup blocked if 87L is ok			x	x	x								x	x	x		x	x	x								x	x	x																				
	Impedance protection:	ZMQPDIS	3	1	21	distance protection 3 zone, quadrilateral	Zone 3 2nd Backup blocked if 87L is ok			x	x	x								x	x	x		x	x	x								x	x	x																				
	Impedance protection:	ZDRDIR	1	1	21D	directional impedance quadrilateral	used for 21																																																	
	Impedance protection:	FDPSPDIS	1	1	21	phase selection, quadrilateral characteristic with fixed angle	used for 21																																																	
	Impedance protection:	ZCVPSOF	1	1		automatic switch onto fault logic, voltage and current based	with meas Zone 2			x	x	x				x(1)				x	x	x		x	x	x				x(1)				x	x	x																				
	Current protection:	EF4PTOC	1	1	51N/67N	Four step residual overcurrent protection	used as 67N			x	x	x								x	x	x		x	x	x								x	x	x																				
	Control:	SESRSYN	1	1	25	synchrocheck, energizing check and synchronizing	used for AR BUS 1 CB																																																	
	Control:	SESRSYN	2	1	25	synchrocheck, energizing check and synchronizing	used for AR Center CB																																																	
	Control:	SMBRREC	1	1	79	autorecloser	1P-3P BUS 1CB												x																																					
	Control:	SMBRREC	2	1	79	autorecloser	1P-3P Center CB																										x																							
	Supervision:	SDDRFUF	1	1		fuse failure supervision	used for 21/67N																																																	
	Monitoring:	LMBRFLO	1	1		fault locator																																																		
	Scheme communication	ZCPSCH	1	1	85	scheme communication logic for distance or overcurrent protection	PUTT with Zone 2			x	x	x						x		x	x	x		x	x	x						x		x	x	x																		x			
	Scheme communication	ZCRWPSCH	1	1	85	current reversal and weak-end infeed logic for distance protection	OFF																																															x			
	Scheme communication	ECPSCH	1	1	85	scheme communication logic for residual overcurrent protection	POTT			x	x	x						x		x	x	x		x	x	x						x		x	x	x																		x			
	Scheme communication	ECRWPSCH	1	1	85	current reversal and weak-end infeed logic for residual overcurrent protection	OFF																																															x			
REL670 -FN2	REL670 V1.2			1		Device information line			x																																													
	Impedance protection:	ZMQPDIS	1	1	21	Distance protection 5 zones, quadrilateral characteristic	Zone 1 Fw						x	x	x			x		x	x	x					x	x	x			x		x	x	x																				
	Impedance protection:	ZMQPDIS	2	1	21	Distance protection 5 zones, quadrilateral characteristic	Zone 2 Fw for Comm																																																		
	Impedance protection:	ZMQPDIS	3	1	21	Distance protection 5 zones, quadrilateral characteristic	Zone 3 first Backup						x	x	x					x	x	x					x	x	x					x	x	x																				
	Impedance protection:	ZMQPDIS	4	1	21	Distance protection 5 zones, quadrilateral characteristic	Zone 4 2nd Backup						x	x	x					x	x	x					x	x	x					x	x	x																				
	Impedance protection:	ZMQPDIS	5	1	21	Distance protection 5 zones, quadrilateral characteristic	Zone 5 Reserve																																																	
	Impedance protection:	ZDRDIR	1	1	21D	directional impedance quadrilateral	used for 21																																																	
	Impedance protection:	FDPSPDIS	1	1	21	Phase selection, quadrilateral characteristic with fixed angle	used for 21																																																	
	Impedance protection:	ZCVPSOF	1	1		automatic switch onto fault logic, voltage and current based	with meas Zone 2						x	x	x	x(1)				x	x	x					x	x	x	x(1)				x	x	x																				
	Current protection:	OC4PTOC	1	1	51/67	Four step phase overcurrent protection	used as 67						x	x	x					x	x	x					x	x	x					x	x	x																				
	Current protection:	EF4PTOC	1	1	51N/67N	Four step residual overcurrent protection	used as 67N						x	x	x					x	x	x					x	x	x					x	x																					
	Control:	SESRSYN	1	1	25	synchrocheck, energizing check and synchronizing	used for AR and Mimic BUS 1 CB																																																	
	Control:	SESRSYN	2	1	25	synchrocheck, energizing check and synchronizing	used for AR and Mimic Center CB																																																	
	Control:	SMBRREC	1	1	79	Autorecloser	1P-3P BUS 1 CB only if AR in Main is blocked												x																																					
	Control:	SMBRREC	2	1	79	Autorecloser	1P-3P Center CB only if AR in Main is blocked																										x																							
	Supervision:	SDDRFUF	1	1		Fuse failure supervision	used for 21/67/67N																																																	
	Monitoring:	LMBRFLO	1	1		Fault locator																																																		
	Scheme communication:	ZCPSCH	1	1	85	scheme communication logic for distance or overcurrent protection	PUTT with Zone 2						x	x	x			x		x	x	x					x	x	x			x		x	x	x																			x	
	Scheme communication:	ZCRWPSCH	1	1	85	current reversal and weak-end infeed logic for distance protection	OFF																																																	x	
	Scheme communication:	ECPSCH	1	1	85	scheme communication logic for residual overcurrent protection	POTT						x	x	x			x		x	x	x					x	x	x			x		x	x	x																			x	
	Scheme communication:	ECRWPSCH	1	1	85	current reversal and weak-end infeed logic for residual overcurrent protection	OFF																																																	x	
TSG -P111					27-	Trip Circuit supervision		x		O	O	O																																												
TSG -P121					27-	Trip Circuit supervision			x				O	O	O																																							
RXMD1 -K15					69-	Latch Relay		x																																														
TSG -P112					TCS	Trip Circuit supervision		x																O	O	O																												
TSG -P122					TCS	Trip Circuit supervision			x																		O	O	O																									
RXMD1 -K25					69-	Latch Relay		x																																														

Legend

x = Initiation
O = Supervision
TC1/2 = Trip Coil 1/2
CC = Close Coil
BCL = Block Close
SC = Logic Transfer Trip
DTT = Direct Transfer Trip

Notes

x(1) = Close block only for Manual close, not for AR Close
x(2)
x(3)
x(4)
x(5)

Based on 1KHF328874			Prepared	Title 230kV Diameter -7 Line to Aminbazar Trip Matrix	Doc. kind. Circuit diagram	Ref.Des. =D1.Q07
AS BUILT 2015-01-14			Approved			
			Project POWER GRID COMPANY OF BANGLADESH 230kV Meghnaghat Substation		Resp. dept.	Rev. ind. / Language en
Rev.	Revision note	Date	Name	ABB Switzerland Ltd.	Doc. no. 1KHF335488	Sheet 22 / n. sheet 31

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+UHFN11

-FN1

RED670 shall be replaced by new relay same as M1FP USED in 143 CT-B/ DC1

67N IN PDEF | 21 3I> PDIST | 87L1 3Id/I PDIF

LINE CT P40#AI.01-03 — I/3

LINE CT P40#AI.04-06 — I/3

LDCM

LINE VT P40#AI.07-09 — U/3

95DR DR RDRE

QA1 — 79 1->0 RREC1 — 25 SC RSYN1 — BUS I VT P40#AI.10 — U/1 — From MAIN BUS I VT

QA3 — 79 1->0 RREC2 — 25 SC RSYN2 — Line 2 VT P40#AI.11 — U/1

BUS 2 VT P40#AI.12 — U/1 — From MAIN BUS 2 VT

-FN2

REL670 Shall be replaced by new relay same as M2FP USED in 143 CT-B/ DC2

67N IN PDEF | 67 3I> PDOC | 21 3I> PDIST

LINE CT AI.01-03 — I/3

LINE CT AI.04-06 — U/3

LINE VT AI.07-09 — U/1

95DR DR RDRE

QA1 — 79 1->0 RREC1 — 25 SC RSYN1 — BUS I VT AI.10

QA3 — 79 1->0 RREC2 — 25 SC RSYN2 — Line 2 VT AI.11

BUS 2 VT AI.12

27-1 DC1 TSG930 | 27-2 DC2 TSG930 | K15 DC1 RXMD1

27-1 DC1 TSG930 | 27-2 DC2 TSG930 | K25 DC1 RXMD1

+UHKF1

-KF1

REC670 / IEC61850 / Control / DC1

Line 1 CVMMXN1 — Line 1 CMMXU1 — LINE1 CT AI.01-03

Line 2 CVMMXN2 — Line 2 CMMXU2 — LINE2 CT AI.1-03

Line 1 VMMXU1 — LINE1 VT AI.07-09

Line 2 VMMXU2 — LINE2 VT AI.07-09

BUS I VMMXU3 — BUS I VT AI.10 — From MAIN BUS I VT

BUS II VMMXU4 — BUS II VT AI.11 — From MAIN BUS II VT

QA1 — 25 SC RSYN1

QA3 — 25 SC RSYN2

QA2 — 25 SC RSYN3

95DR DR RDRE

-SF1

BCM801 / Mimic / Control / DC2

Line 1 CT/VT — Line 1 DFDR

Line 2 CT/VT

Line 2 Metering

Line 1 EM-2 — Line 1 EM-1

MAIN BUS I 230kV ,1600A, 3PH, 40kA for 1Sec,50Hz

-QB1(4) M

-BC1.1 2400/1A, 30VA, CL. 5P20

-BC1.2 2400/1A, 30VA, CL. 5P20

-BC1.3 2400/1A, 30VA, CL. 5P20

-BC1.4 2400/1A, 15VA, CL. 0.2S — METERING PANEL

-BC1.5 2400/1A, 30VA,CL PX

-QA1(1)

-BC2.1 2400/1A, 30VA, CL. 5P20

-BC2.2 2400/1A, 30VA, CL. 5P20

-BC2.3 2400/1A, 30VA, CL. 5P20

-BC2.4 2400/1A, 15VA, CL. 0.2S

-BC2.5 2400/1A, 30VA,CL PX — BU 6MU85

-QB61(5) M

-BA1 — 110V/√3 110V/√3 230kV/√3 — 150VA, 0.5/3P 150VA, 0.5/3P

-BA91 — 230kV/√3 110V/√3 110V/√3 — 150VA, 0.5/3P

-QB91(6) — To ATR03

-QB63(8) M

-QC91(7)

-BC3.1 2400-1600/1A, 30VA, CL. 5P20 — FN1 SMPL2

-BC3.2 2400-1600/1A, 30VA, CL. 5P20 — FN2 SMPL2

-BC3.3 2400-1600/1A, 30VA, CL. 5P20

-BC3.4 2400-1600/1A, 15VA, CL. 0.2S

-BC3.5 2400-1600/1A, 30VA,CL PX — 7VK87

-QA3(2)

-BC 4.5 2400-1600/1A, 30VA, CL. PX — 7VK87

-BC 4.4 2400-1600/1A, 15VA, CL. 0.2S

-BC 4.3 2400-1600/1A, 30VA, CL. 5P20

-BC 4.2 2400-1600/1A, 30VA, CL 5P20

-BC4.1 2400-1600/1A, 30VA,CL 5P20

-QB64(9) M

-BA2 — 110V/√3 110V/√3 230kV/√3 — 150VA, 0.5/3P 150VA, 0.5/3P

-BA92 — 230kV/√3 110V/√3 110V/√3 — 150VA, 0.5/3P

-QB92(12) — to Generating Stn Meghnaghat Power Plant

-QB62(11) M

-QC92(13)

-BC 5.5 2400-1600/1A, 30VA, CL. PX — BU 6MU85

-BC 5.4 2400-1600/1A, 15VA, CL. 0.2S

-BC 5.3 2400-1600/1A, 30VA, CL. 5P20

-BC 5.2 2400-1600/1A, 30VA, CL. 5P20

-BC5.1 2400-1600/1A, 30VA,CL 5P20

-QA2(3)

-BC 6.5 2400-1600/1A, 30VA, CL. PX

-BC 6.4 2400-1600/1A, 15VA, CL. 0.2S

-BC 6.3 2400-1600/1A, 30VA, CL. 5P20

-BC 6.2 2400-1600/1A, 30VA, CL 5P20 — FN2 SMPL2

-BC6.1 2400-1600/1A, 30VA,CL 5P20 — FN1 SMPL2

-QB2(10) M

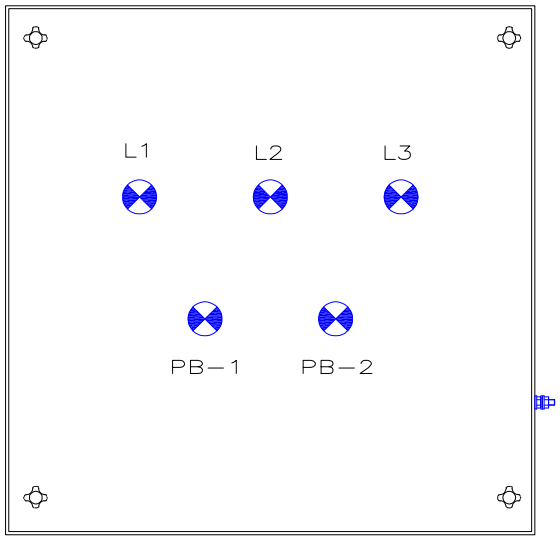
230kV ,1600A, 3PH, 40kA for 1Sec,50Hz

SCOPE

AFTER RECONNECTION ALL IED'S TO BE TESTED

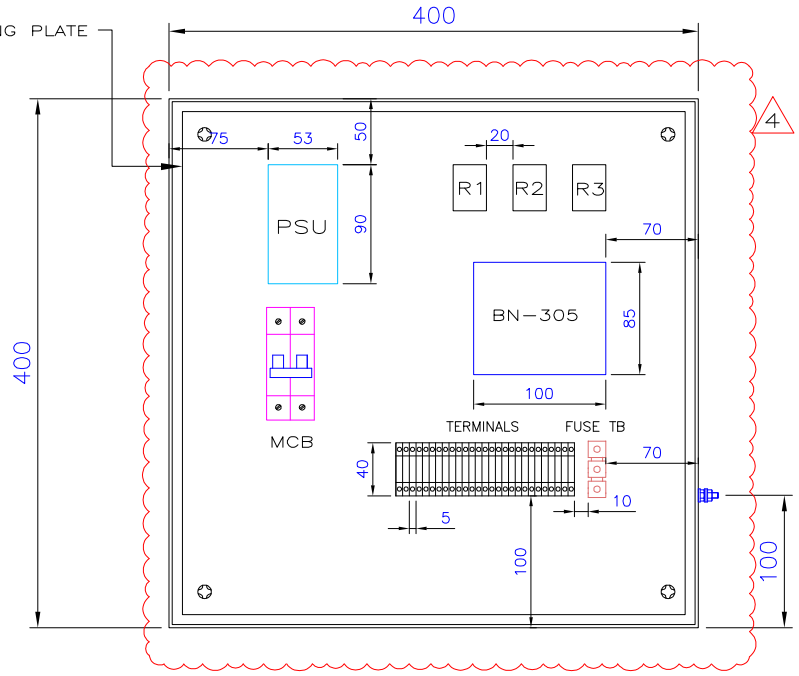
CONTROL VOLTAGE 220Vdc for this complete substation

Based on 1KHF328874				Prepared	Title 230kV Diameter -7 Line to Aminbazar Block diagram	Doc. kind. Circuit diagram	Ref.Des. =D1.Q07
				Approved			
				Project POWER GRID COMPANY OF BANGLADESH 230kV Meghnaghat Substation		Resp. dept.	Rev. ind. / Language
Rev.	Revision note	Date	Name			Doc. no.	Sheet 21 / n. sheet 22

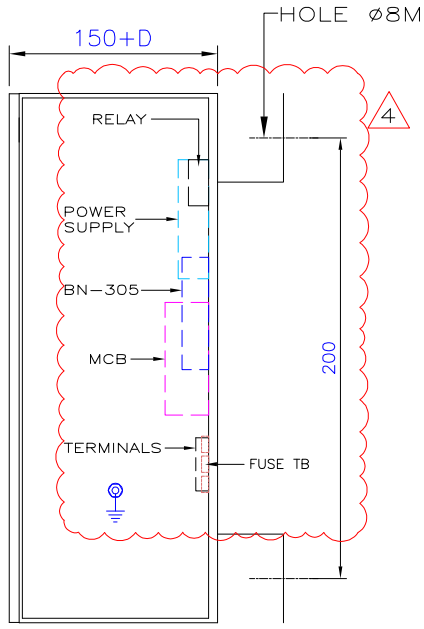


FRONT VIEW

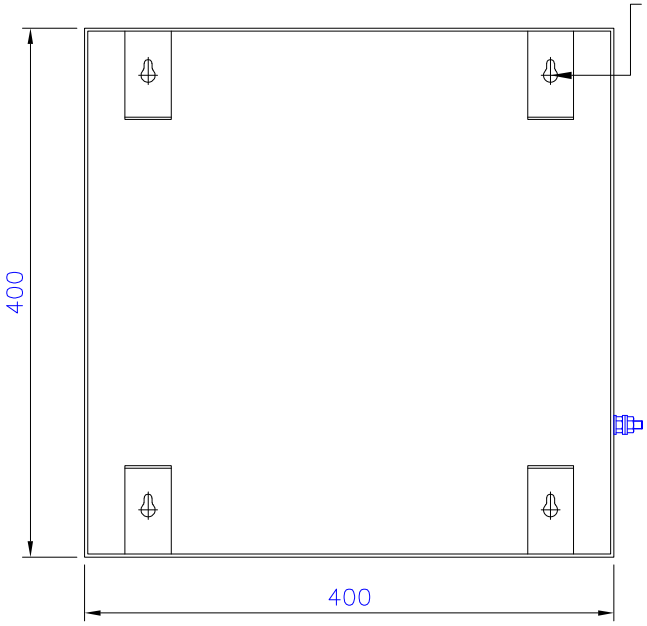
WITH REMOVABLE COVER



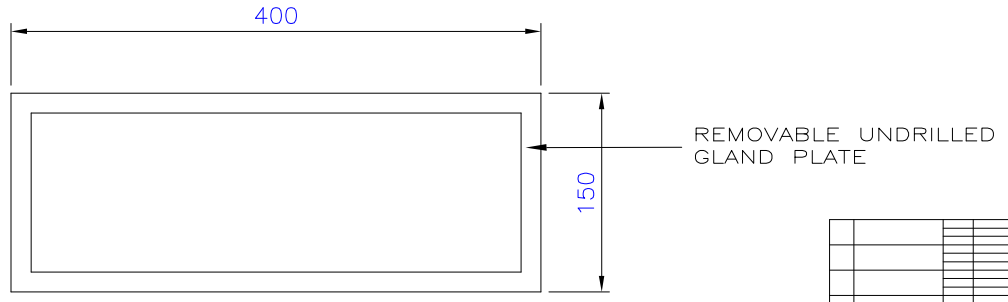
INSIDE VIEW



SIDE VIEW



REAR VIEW

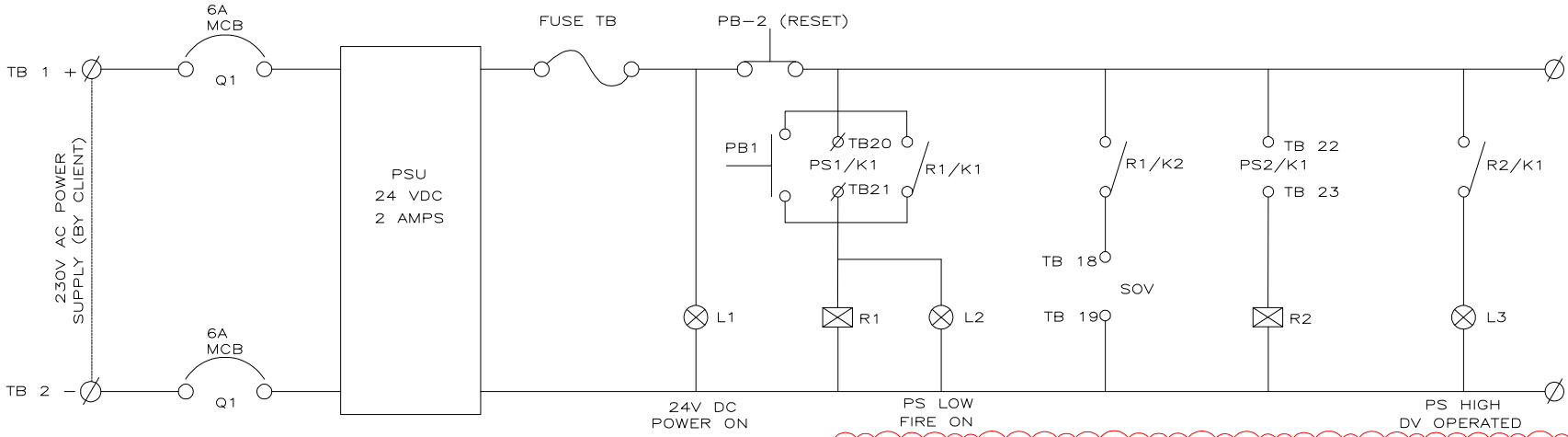


BOTTOM VIEW

DELUGE VALVE CONTROL PANEL

TITLE: G.A. AND WIRING DIAGRAM OF DELUGE VALVE CONTROL PANEL

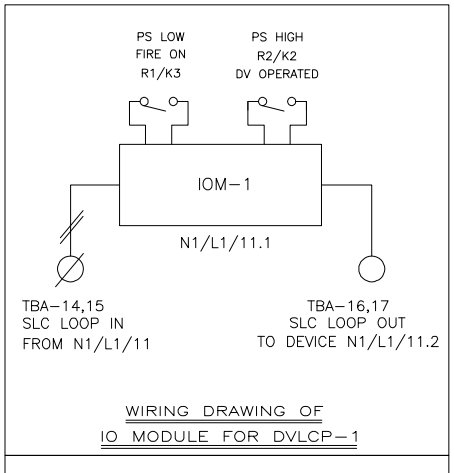
SHT	A3		Dwg No:	Total sht:	Sheet No:	Rev No:
SCALE	NTS		MKSI-052913-GA-55003	03	02	03



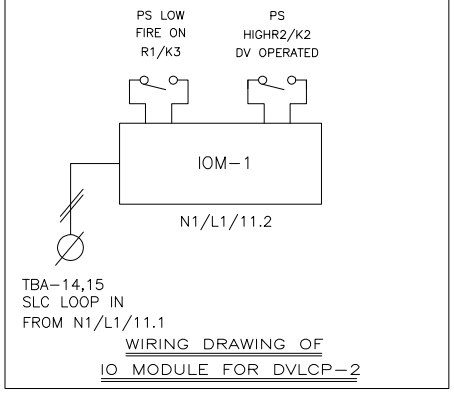
BILL OF MATERIAL

SR.No.	LEGEND	COMPONENTS	QTY	MAKE
1	Q1	MCB 2 POLE 6A 240VAC	01	SCHNEIDER
2	∿	24V DC 6 AMP FUSE TERMINAL	01	---
3	PB–1	PUSH BUTTON FOR DV OPERATION (GREEN COLOR)	01	TEKNIC
4	PB–2	PUSH BUTTON FOR SYSTEM RESET (RED COLOR)	01	TEKNIC
5	L1	GREEN COLOR INDICATING LAMP 24 VDC POWER ON	01	TEKNIC
6	L2	RED COLOR INDICATING LAMP–PS LOW	01	TEKNIC
7	L3	ORANGE COLOR INDICATING LAMP– PS HIGH	01	TEKNIC
8	R1	RELAY 24 VDC– (3 CHANGE OVER CONTACT FOR FIRE ON INDICATION L2 AND SOV OPERATION AND INDICATION ON FAP	01	OEN/OMRON
9	R2	RELAY 24 VDC– (3 CHANGE OVER CONTACT FOR DV OPERATED INDICATION L3 AND INDICATION ON FAP)	01	OEN/OMRON
10	TB	TERMINAL BLOCKS	AS REQ	CONNECTWELL/ELMAX
11	PSU	POWER SUPPLY 24V DC 2 AMP	01	MEANWELL MODEL NO HDR–60–24
12	IOM	INPUT OUTPUT MODULE	01	AUTRONICA MODEL NO–BN–305

4



WIRING DRAWING OF
IO MODULE FOR DVLCP–1



WIRING DRAWING OF
IO MODULE FOR DVLCP–2

4

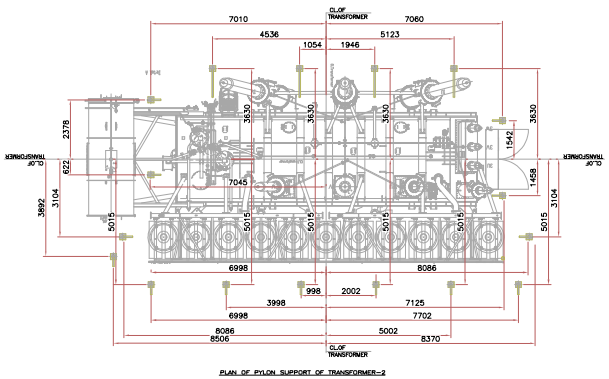
TBA		TBA	
1	230V AC POWER SUPPLY (BY CLIENT)	16	LOOP OUT
2		17	
3		18	SOLENOID VALVE
4	SPARE	19	
5		20	PRESSURE SWITCH PS–1 LOW (PS1/K1)
6	SPARE	21	
7		22	PRESSURE SWITCH PS–2 HIGH (PS2/K1)
8	SPARE	23	
9		24	SPARE
10	SPARE	25	
11		26	SPARE
12	SPARE	27	
13			
14	LOOP IN		
15			

DELUGE VALVE CONTROL PANEL

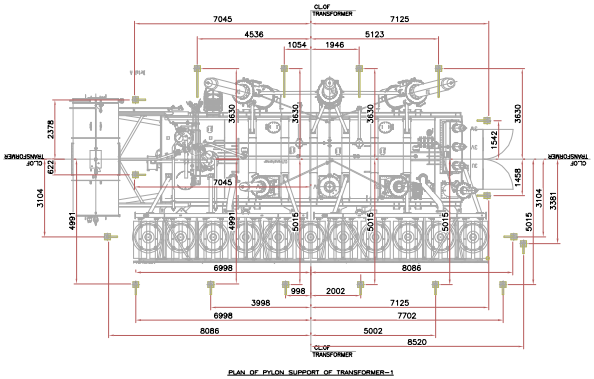
FIRE FIGHTING CONTRACTOR, M/s. Systems International Pvt. Ltd.

TITLE: G.A. AND WIRING DIAGRAM OF DELUGE VALVE CONTROL PANEL

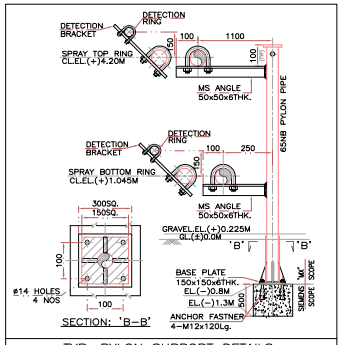
SHT	A3		Dwg No:	Total sht:	Sheet No:	Rev No:
SCALE	NTS		MKSI-052913-GA-55003	03	03	03



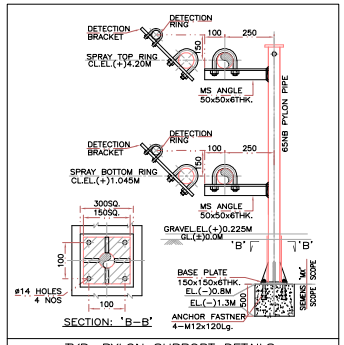
PLAN OF PYLON SUPPORT OF TRANSFORMER-2



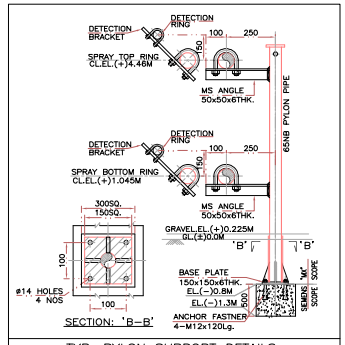
PLAN OF PYLON SUPPORT OF TRANSFORMER-1



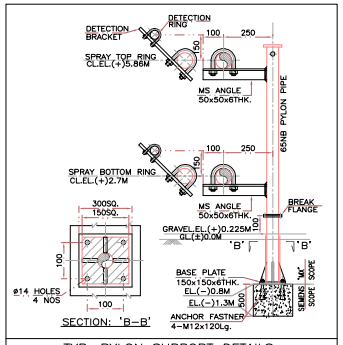
TYP. PYLON SUPPORT DETAILS
PS1=08NOS.



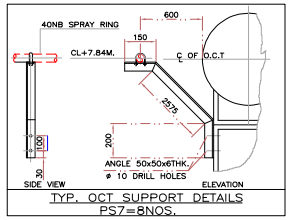
TYP. PYLON SUPPORT DETAILS
PS2=04NOS.



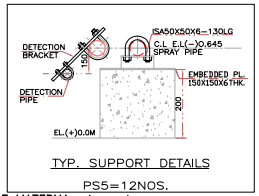
TYP. PYLON SUPPORT DETAILS
PS2A=04NOS.



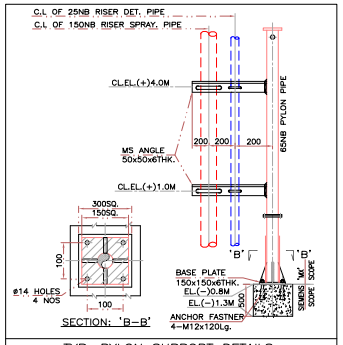
TYP. PYLON SUPPORT DETAILS
PS3=16NOS.



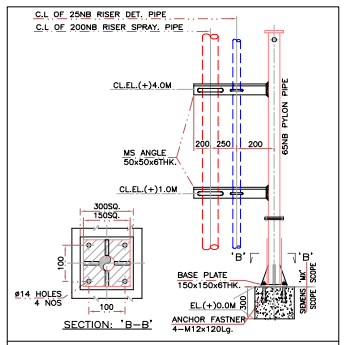
TYP. OCT SUPPORT DETAILS
PS7=8NOS.



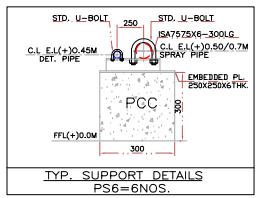
TYP. SUPPORT DETAILS
PS5=12NOS.



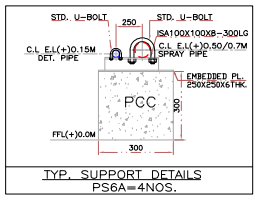
TYP. PYLON SUPPORT DETAILS
PS4=1NOS.



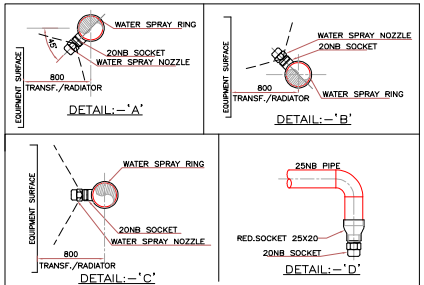
TYP. PYLON SUPPORT DETAILS
PS4A=1NOS.



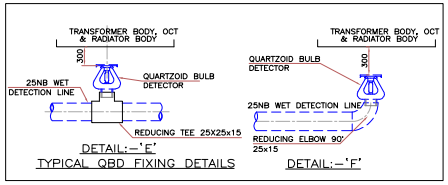
TYP. SUPPORT DETAILS
PS6=6NOS.



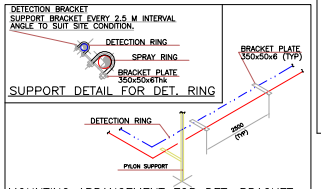
TYP. SUPPORT DETAILS
PS6A=4NOS.



TYPICAL NOZZLE MOUNTING DETAILS



TYPICAL QBD FIXING DETAILS



MOUNTING ARRANGEMENT FOR DET. BRACKET

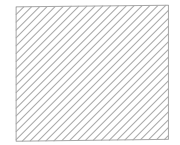
BILL OF MATERIAL:− (MS PIPE)

ITEM	100NB	65NB	25NB
PIPE A/G	24.0 M.	180.0 M.	480 M.
FLANGE	12NOS	64NOS.	68NOS.
GASKET	12NOS.	32NOS.	34NOS.
ELBOW 90°	06NOS.		88NOS.
RED ELBOW	−−		25X15=40NOS.
RED.TEE(25X25X15)	−−		15NB=106NOS.
RED.SOCKET			25X15=24NOS.
STD "U" BOLT	12U BOLT	06 NOS.	
	10U BOLT	08 NOS.	
	8U BOLT	76 NOS.	
	6U BOLT	98 NOS.	
M.S. PLATE 250x250x6THK.=12NO			
M.S. PLATE 150x150x6THK.=46NOS.			
M.S ANGLE 100x100x8THK. = 1.5M.			
M.S ANGLE 75x75x6THK. = 2.0M.			
M.S ANGLE 50x50x6THK. = 58.0M.			
ANCHOR FASTNER M12X120 LG = 144 NOS.			
DETECTION BRACKET 350X350X6 = 106 NOS.			
100ø X 6THK MS. PLATE = 34 NOS.			
GI. NUT BOLT, NUT & WASHER (200ø) − M22x110L=16NOS			
GI. NUT BOLT, NUT & WASHER (150ø) − M20x110L=64NOS			
GI. NUT BOLT, NUT & WASHER (100ø) − M16x90L = 96NOS			
GI. STUD BOLT, NUT & WASHER (100ø) − M16x95L = 48NOS			
GI. NUT BOLT, NUT & WASHER (80ø) − M16x90L = 52NOS			
GI. NUT BOLT, NUT & WASHER (65ø) − M16x85L = 176NOS			
GI. NUT BOLT, NUT & WASHER (40ø) − M12x65L = 16NOS			
GI. NUT BOLT, NUT & WASHER (25ø) − M12x55L = 136NOS			

BILL OF MATERIAL:− (GI PIPE)

ITEM	200NB	150NB	100NB	80NB	65NB	40NB	25NB	20NB	15NB
PIPE	36.0M	60.0M	12.0M	120.0M	144.0M	42.0M.	108.0M		−−
DELUGE VALVE			02 NOS.						
BUTTERFLY VALVE			06 NOS.						
Y−STRAINER			02 NOS.						
SPRAY NOZZLE K=23,ANGLE=120°			170 NOS.						
QUARTZOID BULB DETECTOR−79°C.			170 NOS.						
FLANGE	08 NOS.	16 NOS.	08 NOS.	20 NOS.	24 NOS.	08 NOS.	−−		−−
GASKET	04 NOS.	04 NOS.	04 NOS.	10 NOS.	12 NOS.	04 NOS.	−−		−−
ELBOW 90°	10 NOS.	12 NOS.	04 NOS.	16 NOS.	24 NOS.	08 NOS.	16 NOS.		−−
RED ELBOW 90°			−−			−−		25x20=40	−−
SOCKET (THD.)			−−			−−	−−	106 NOS.	
EQUAL TEE									
REDUCER	200x150=04 200x100=02	150x80=08		80x40=04					−−
RED SOCKET			−−			−−		25x20=24	−−

LEGEND:−



LEGEND:−

SR.NO.	SYMBOL	DESCRIPTION
1.		FIRE WATER SPRAY LINE (UNDER GROUND)
2.		FIRE WATER SPRAY LINE (ABOVE GROUND)
3.		WET DETECTION LINE (UNDER GROUND)
4.		WET DETECTION LINE (ABOVE GROUND)
5.		QUARTZOID BULB DETECTOR − 79°C.
6.		WATER SPRAY NOZZLE
7.		DELUGE VALVE (DV)
8.		BUTTERFLY VALVE (BFV)
9.		"Y" TYPE STRAINER (STR)
10.		CON. REDUCER (RED)
11.		FLANGE JOINT
12.		PYLON SUPPORT FOUNDATION

DESIGN PARAMETER:− (TRANSFORMER BAY−I)

SR. NO.	DESCRIPTION	
00	TRANSFORMER	TRF@ I 750MVA
01	DESIGN CODE	TAC / NFPA
02	PART NAME:−	DIMENSIONS:−
	a) TRANSFORMER BODY	=[(Lw) + 2(Ls)] + 2(Ws)π =2[(11.8x3.42)+2(11.8x3.42)+2(3.42x3.42) = 184.82M²
	b) RADIATOR BODY	=[(Lw) + 2(Ls)] + 2(Ws)π =2[(14.175x1.485)+2(14.175x3.0)+2(1.485x3.0)] = 136.06M²
	c) OIL CONSERVATOR TANK	=πR² +πRL =(3.14x1.4²)2 +3.14 x ø1.8 x 4.695 = 31.51M²
03	TOTAL PROTECTED AREA	= 352.39 M²
04	RATE OF APPLICATION	10.2Lpm/M²
05	PRESSURE REQUIREMENT FOR SYSTEM	3.5 TO 5.0 Kg/Cm²
06	SPRAY NOZZLE TYPE & K−FACTOR/ ANGLE	HO3/4" x K=23/120DEG. = 85Nos.
07	THEORETICAL WATER REQUIREMENT	= 3594.34 Lpm.
08	ACTUAL WATER PROVIDED AS PER HYDRAULIC CALCULATIONS	TRANSFORMER−1 = 3856.66 Lpm. TRANSFORMER−2 = 3890.14 Lpm.
09	PRESSURE AVAILABLE AT TAP−OFF	= 8.0 Kg/Cm²
10	DELUGE VALVE PROVIDED AS PER	= 100 NB
11	QUARTZOID BULB DETECTOR 79°C	= 85Nos.

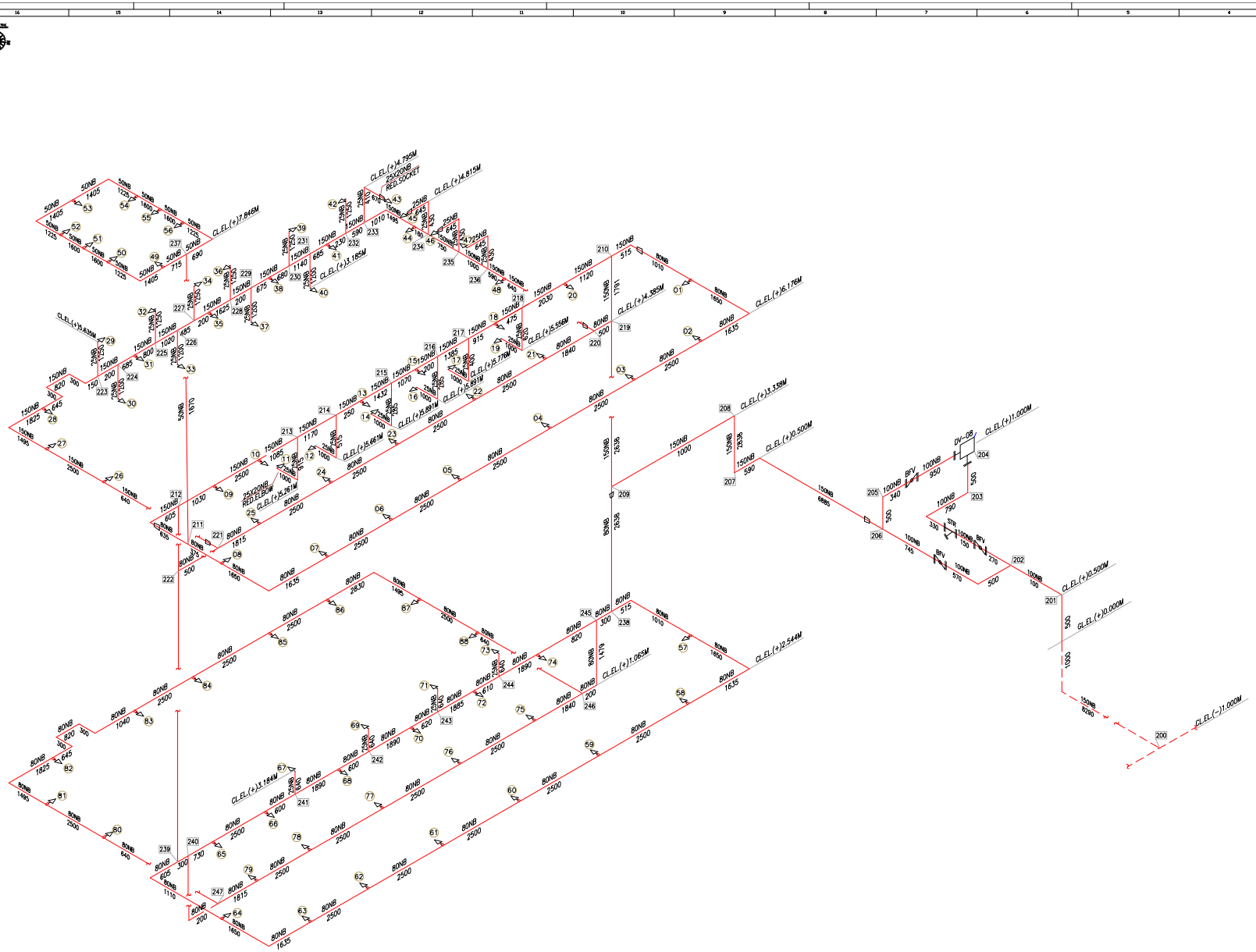
NOTES:−

01. SYSTEM DESIGNED AS PER TAC/NFPA REGULATIONS FOR TRANSFORMER PROTECTION.
02. ALL DIMENSION ARE IN MM & CO−ORDINATES ARE IN MTRS.
03. DISTANCE BETWEEN TWO DETECTORS SHALL NOT BE MORE THAN 2.5 MTRS & HIGH FROM THE FFL. SHALL BE 3.0 MTRS.
04. ACTIVATION TEMPERATURE OF DETECTOR SHALL BE 79°C.
05. IF ANY FOULING AT SITE THE RING DISTANCE CAN BE MODIFIED BUT THE SPRAY NOZZLE DISTANCE FROM THE EQUIPMENT SURFACE SHOULD BE WITHIN 800 MM. DETECTION LOCATION SHOULD BE MAINTAINED WITHIN 300 MM FROM THE EQUIPMENT SURFACE.
06. BREAK FLANGES SHALL ONLY BE PROVIDED AT THE PYLON PIPE WHEREVER THERE IS MOVEMENT OF TRANSFORMER FOR MAINTENANCE.
07. ALL U/G PIPING SHALL BE PROVIDED WITH WRAPPING & COATING.
08. PIPE SUPPORT (PYLON) SHALL BE PROVIDED TO SUITE SITE LOCATION.
09. MINIMUM ELECTRICAL CLEARANCE AS INDICATED IN THE TABLE ... SHALL BE MAINTAINED FOR PIPES/HANGERS.
10. BEFORE FABRICATION OF THE HEADER, SPRAY PIPING, DRAWING SHALL BE PHYSICALLY COORDINATED WITH THE ACTUAL TRANSFORMER DIMENSION TO AVOID RE WORK.
11. PIPE SHALL BE TESTED HYDROTESTED BEFORE DELUGE VALVE ONLY.

TITLE: Layout & Isometric view of HVW Spray System for 750 MVA Transformers

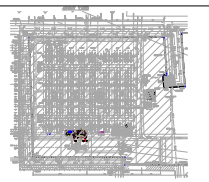
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SCALE 1:100			03	03 OF 03	01

A0 Sheet



ISOMETRIC VIEW

LEGEND:-



LEGEND:-

SR.NO.	SYMBOL	DESCRIPTION
1.		FIRE WATER SPRAY LINE (UNDER GROUND)
2.		FIRE WATER SPRAY LINE (ABOVE GROUND)
3.		WET DETECTION LINE (UNDER GROUND)
4.		WET DETECTION LINE (ABOVE GROUND)
5.		QUARTZOID BULB DETECTOR – 79°C.
6.		WATER SPRAY NOZZLE
7.		DELUGE VALVE (DV)
8.		BUTTERFLY VALVE (BFV)
9.		'Y' TYPE STRAINER (STR)
10.		CON. REDUCER (RED)
11.		FLANGE JOINT
12.		PYLON SUPPORT FOUNDATION

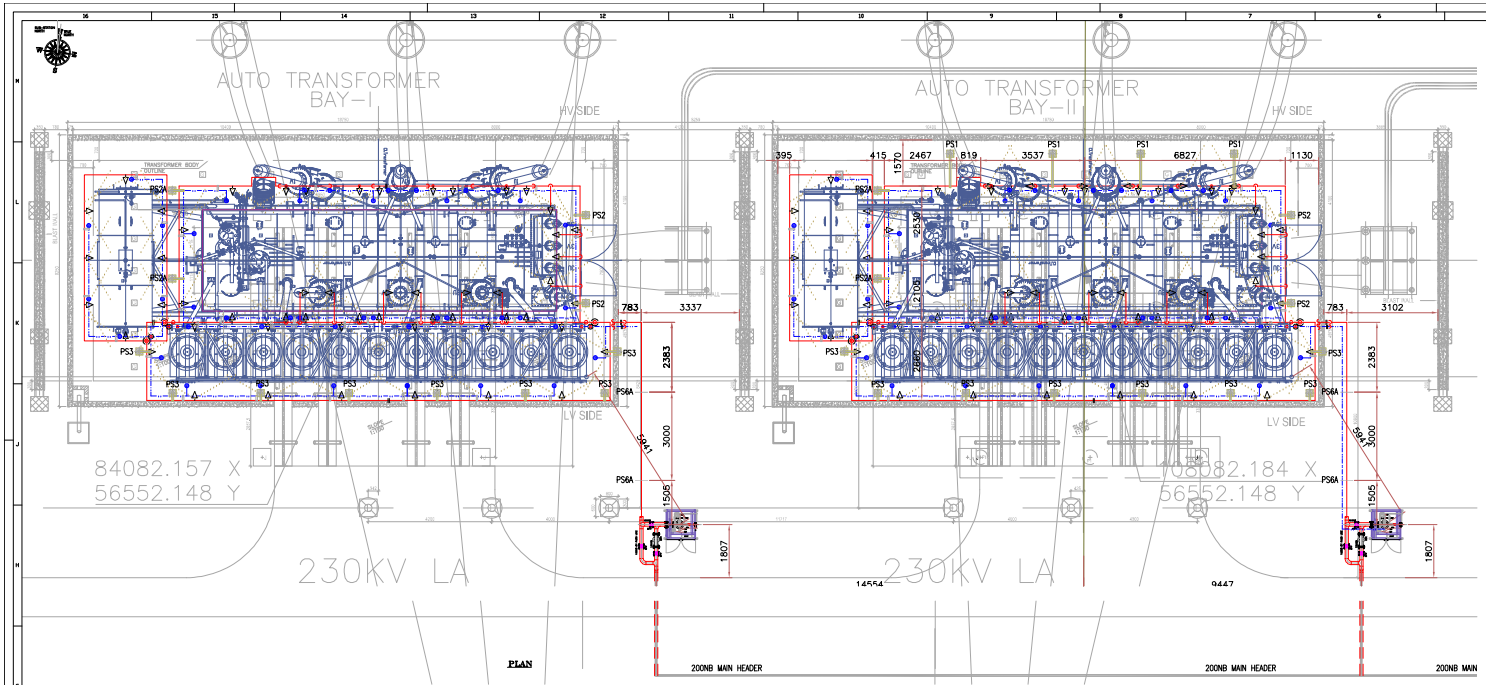
NOTES:-

01. SYSTEM DESIGNED AS PER TAC/NFPA REGULATIONS FOR TRANSFORMER PROTECTION.
02. ALL DIMENSION ARE IN MM & CO-ORDINATES ARE IN MTRS.
03. DISTANCE BETWEEN TWO DETECTORS SHALL NOT BE MORE THAN 2.5 MTRS & HIGH FROM THE FFL. SHALL BE 3.0 MTRS.
04. ACTIVATION TEMPERATURE OF DETECTOR SHALL BE 79°C.
05. IF ANY FOULING AT SITE THE RING DISTANCE CAN BE MODIFIED BUT THE SPRAY NOZZLE DISTANCE FROM THE EQUIPMENT SURFACE SHOULD BE WITHIN 800 MM. DETECTION LOCATION SHOULD BE MAINTAINED WITHIN 300 MM FROM THE EQUIPMENT SURFACE.
06. BREAK FLANGES SHALL ONLY BE PROVIDED AT THE PYLON PIPE WHEREVER THERE IS MOVEMENT OF TRANSFORMER FOR MAINTENANCE.
07. ALL U/G PIPING SHALL BE PROVIDED WITH WRAPPING & COATING.
08. PIPE SUPPORT (PYLON) SHALL BE PROVIDED TO SUITE SITE LOCATION.
09. SUITABLE ELECTRICAL CLEARANCE AS INDICATED IN THE TABLE .. SHALL BE MAINTAINED FOR PIPES/NOZZLES.
10. BEFORE FABRICATION OF THE HEADER, SPRAY PIPING RING, DRAWING SHALL BE PHYSICALLY CORDINATED WITH THE ACTUAL TRANSFORMER DIMENSION TO AVOID RE WORK.
11. PIPE SHALL BE TESTED HYDROTESTED BEFORE DELGUE VALVE ONLY.

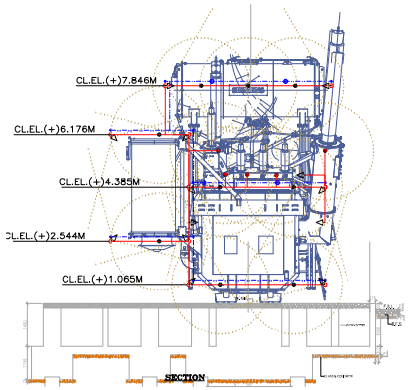
TITLE: Layout & Isometric view of HVW Spray System for 750 MVA Transformers

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SCALE:	1:100			03	02 OF 03	01

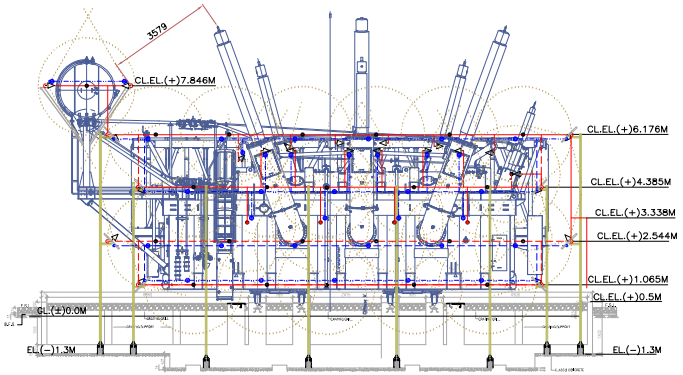
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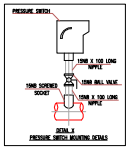
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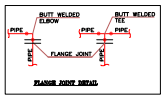


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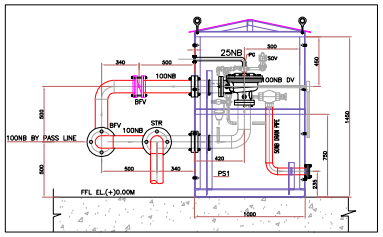
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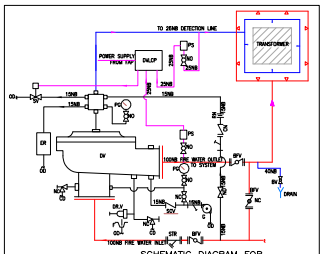


ELECTRICAL CLEARANCE CHART

SL. NO.	RISK	MINIMUM CLEARANCE DISTANCE FROM PIPE TO RISK IN MM	MINIMUM CLEARANCE DISTANCE FROM NOZZLE TIP TO RISK IN MM
1.	MAIN BODY OF TRANSFORMER	800	700
2.	RADIATOR	800	700
3.	CONSERVATOR OIL	600	500



DETAIL OF DELUGE VALVE SKID

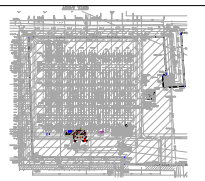


SCHEMATIC DIAGRAM FOR HWS SPRAY SYSTEM

SCHEMATIC LEGEND :–

SL. NO.	SYMBOL	DESCRIPTION	SL. NO.	SYMBOL	DESCRIPTION
1		FIRE WATER SPRAY PIPE LINE	10	FAP	FIRE ALARM PANEL
2		DETECTION LINE	11	PS	PRESSURE SWITCH
3		CABLE	12	SV	SOLENOID VALVE
4		DELUGE VALVE (DV)	13	BV NC	BALL VALVE NORMALLY CLOSE (BV)
5		BUTTERFLY VALVE (BFV) NO NORMALLY OPEN	14	BV NO	BALL VALVE NORMALLY OPEN (BV)
6		BUTTERFLY VALVE (BFV) NC NORMALLY CLOSE	15		ANNUNCIATION
7		"Y" TYPE STRAINER (STR)	16	M	WATER MOTOR GONG
8		SPRAY NOZZLE	17	PG	PRESSURE GAUGE
9		QLB DETECTOR			

LEGEND:–



LEGEND:–

SR.NO.	SYMBOL	DESCRIPTION
1.		FIRE WATER SPRAY LINE (UNDER GROUND)
2.		FIRE WATER SPRAY LINE (ABOVE GROUND)
3.		WET DETECTION LINE (UNDER GROUND)
4.		WET DETECTION LINE (ABOVE GROUND)
5.		QUARTZOID BULB DETECTOR – 79°C.
6.		WATER SPRAY NOZZLE
7.		DELUGE VALVE (DV)
8.		BUTTERFLY VALVE (BFV)
9.		"Y" TYPE STRAINER (STR)
10.		CON. REDUCER (RED)
11.		FLANGE JOINT
12.		PYLON SUPPORT FOUNDATION

DESIGN PARAMETER:–

SL. NO.	DESCRIPTION	TRF#1 750MVA
01	DESIGN CODE	TAC / NFPA
02	PART NAME:–	DIMENSION:–
	a) TRANSFORMER BODY	=2(Lw) + 2(Lw1) + 2(Ww1) =2(11.8x3.42)+2(11.8x3.42)+2(3.42x3.42) = 184.82M²
	b) RADIATOR BODY	=2(Lw1) + 2(Lw2) + 2(Ww2) =2(14.175x1.485)+2(14.175x3.0)+2(1.485x3.0)= 136.06M²
	c) OIL CONSERVATOR TANK	=Pi x dm =(3.14 x 1.4²) /2 +3.14 x 41.8 x 4.695 = 31.51M²
03	TOTAL PROTECTED AREA	= 352.39 M²
04	RATE OF APPLICATION	10.2Lpm/M²
05	PRESSURE REQUIREMENT FOR SYSTEM	3.5 TO 5.0 Kg/Cm²
06	SPRAY NOZZLE TYPE & K=FACTOR/ ANGLE	HD3/4" x K=23/120DEG. = 88Nos.
07	THEORETICAL WATER REQUIREMENT	= 3594.34 Lpm.
08	ACTUAL WATER PROVIDED AS PER HYDRAULIC CALCULATIONS	TRANSFORMER–1 = --- Lpm. TRANSFORMER–2 = --- Lpm.
09	PRESSURE AVAILABLE AT TAP–OFF	= 6.0 Kg/Cm²
10	DELUGE VALVE PROVIDED AS PER	= 100 NB
11	QUARTZOID BULB DETECTOR 79°C	= 88Nos.

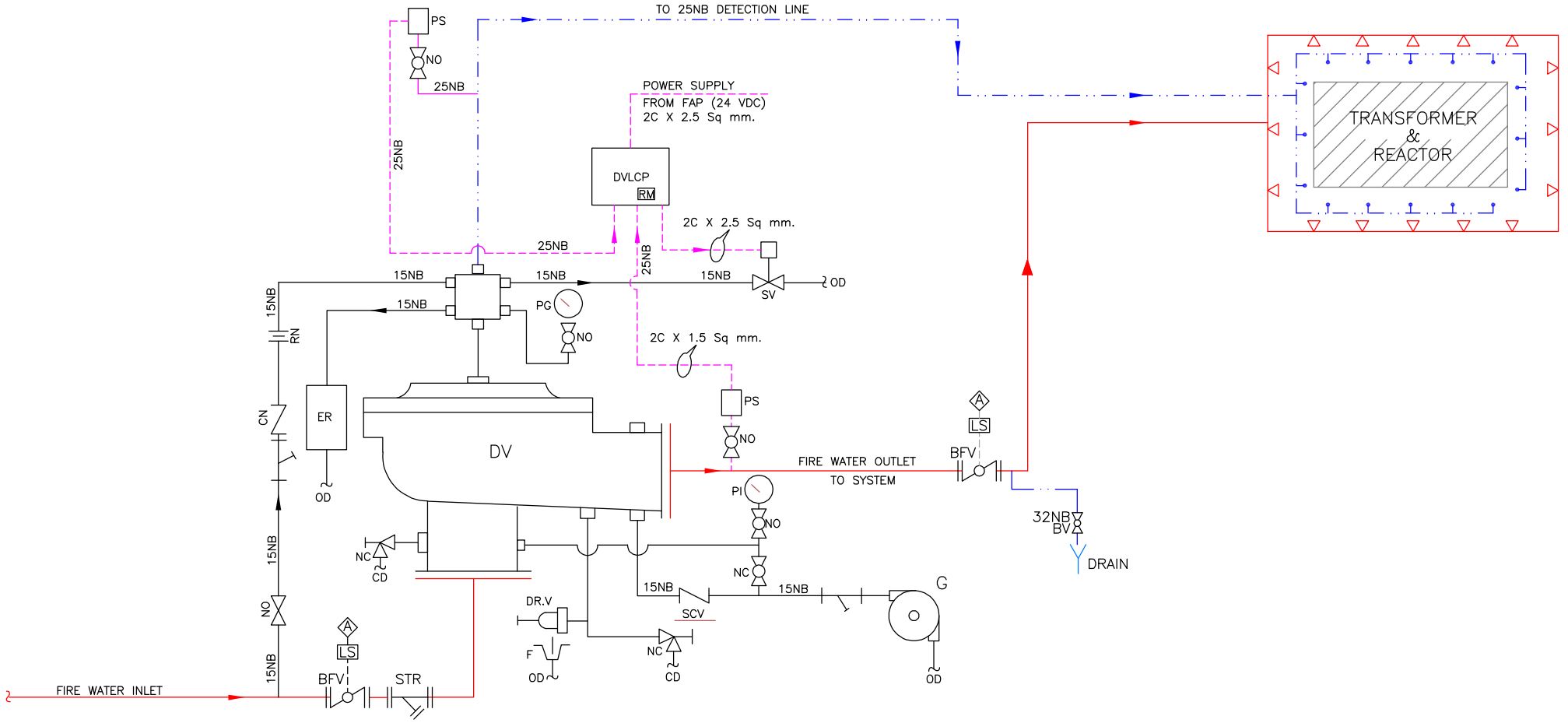
NOTES:–

01. SYSTEM DESIGNED AS PER TAC/NFPA REGULATIONS FOR TRANSFORMER PROTECTION.
02. ALL DIMENSION ARE IN MM & CO–ORDINATES ARE IN MTRS.
03. DISTANCE BETWEEN TWO DETECTORS SHALL NOT BE MORE THAN 2.5 MTRS & HIGH FROM THE FFL. SHALL BE 3.0 MTRS.
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06. Ⓜ BREAK FLANGES SHALL ONLY BE PROVIDED AT THE PYLON PIPE WHEREVER THERE IS MOVEMENT OF TRANSFORMER FOR MAINTENANCE.
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09. BEFORE FABRICATION OF THE HEADER, SPRAY PIPING RING, DRAWING SHALL BE PHYSICALLY CORDINATED WITH THE ACTUAL TRANSFORMER DIMENSION TO AVOID RE WORK.
10 PIPE SHALL BE TESTED HYDROTESTED BEFORE DELUGE VALVE ONLY.

OWNER: POWER GRID COMPANY OF BANGLADESH LIMITED

TITLE: Layout & Isometric view of HVW Spray System for 750 MVA Transformers

SHT	A1	Dwg No:	Total sht: Sheet No:	Rev No:
SCALE: 1:100		MXSI–XXXXX–LY–55002	03 01 OF 03	01



AUTOMATIC HVW SPRAY SYSTEM

LEGEND

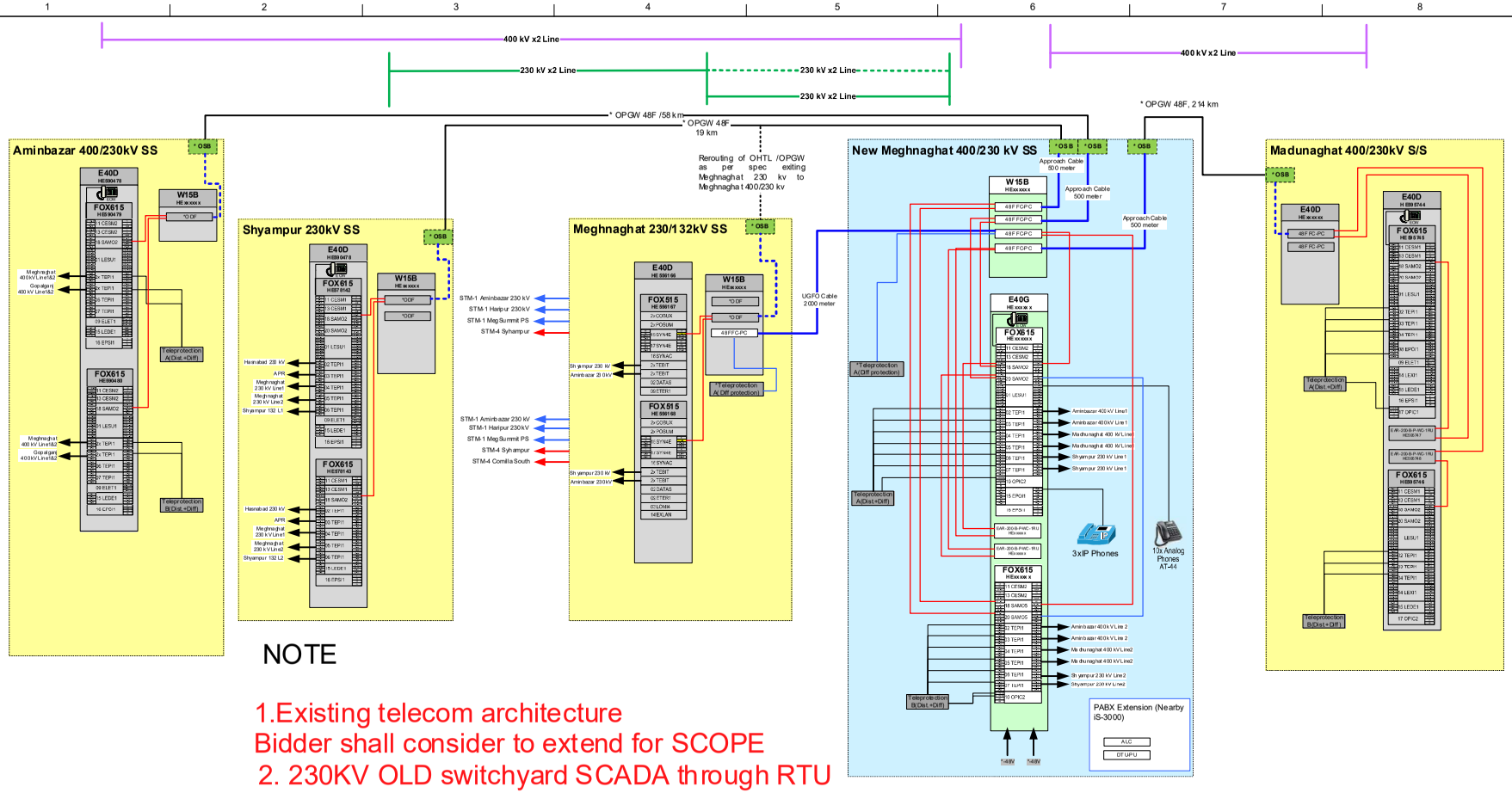
SR. NO.	SYMBOL	DESCRIPTION	SR. NO.	SYMBOL	DESCRIPTION
1		FIRE WATER SPRAY PIPE LINE	10	FAP	FIRE ALARM PANEL
2		DETECTION LINE	11	PS	PRESSURE SWITCH
3		CABLE	12	S	SOLENOID VALVE
4		DELUGE VALVE (DV)	13	NC	BALL VALVE NORMALLY CLOSE (BV)
5		BUTTERFLY VALVE (BFV)	14	NO	BALL VALVE NORMALLY OPEN (BV)
6		'Y' TYPE STRAINER (STR)	15	A	ANNUNCIATION
7		SPRAY NOZZLE	16		WATER MOTOR GONG
8		Q.B DETECTOR	17	PG	PRESSURE GAUGE
9	LS	LIMIT SWITCH	18		ORIFICE

DELUGE VALVE SCHEDULE:–

SR. No.	DV TAG	QTY.	PROTECTED AREA	P.S SET PRESS. kg/cm2	
				FIRE	SPRAY ON
1.	DV–01	1 NOS.	750 MVA TRANSFORMERS–1 , NEAR 2DT6 2 CIRCUIT TOWER	5	2
2.	DV–02	1 NOS.	750 MVA TRANSFORMERS–2 , NEAR 2DT6 2 CIRCUIT TOWER	5	2
3.	DV–03	1 NOS.	40 MVAR REACTOR , NEAR 2DT6 2 CIRCUIT TOWER	5	2

TITLE: P & I Diagram for Spary System

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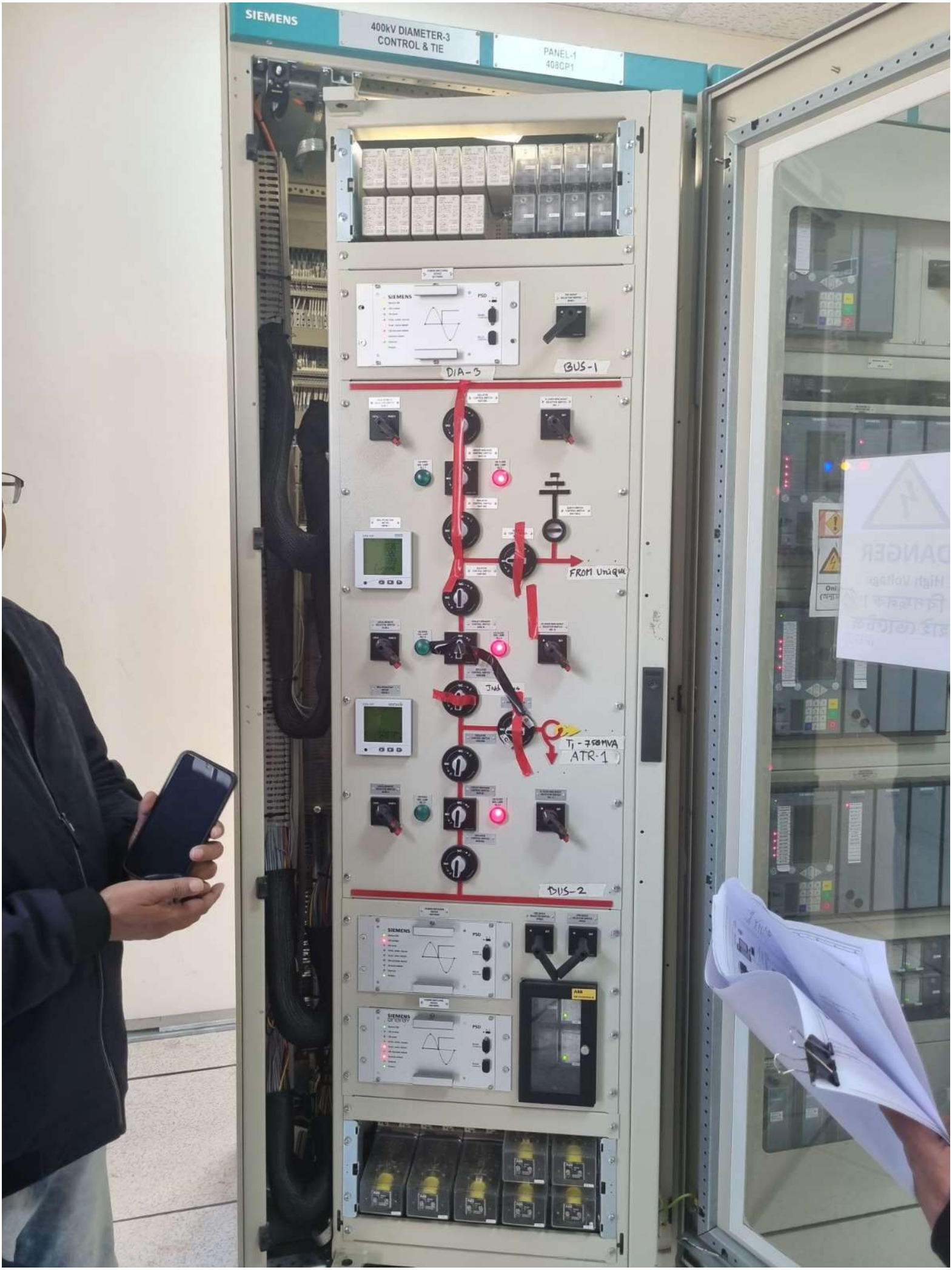


NOTE

1.Existing telecom architecture
Bidder shall consider to extend for SCOPE
2. 230KV OLD switchyard SCADA through RTU (MiCOM C264).
3.tele protection has to be established for 230kv line

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Revision			Revision								
	0	20-04-22/RAK				Prepared	20-04-22/RAK	CUSTOMER: PGCB	Hitachi Energy	PGGA-C	Title: TELECOMMUNICATION SYSTEM SYSTEM LAYOUTS	SDH Equipment	= +
						Reviewed	20-04-22/GID	PROJECT: Meghnaghat 400/230kV SS	Hitachi Energy Switzerland Ltd		BROADBAND SYSTEM		
						Approved	20-04-22/MB	HITACHI NO: 024481	Repl. by		Doc. vsd Format 3 Lang.: EN	1KHD678663	Sheet 3 / No.of sh. 6
						Based on		Repl.					

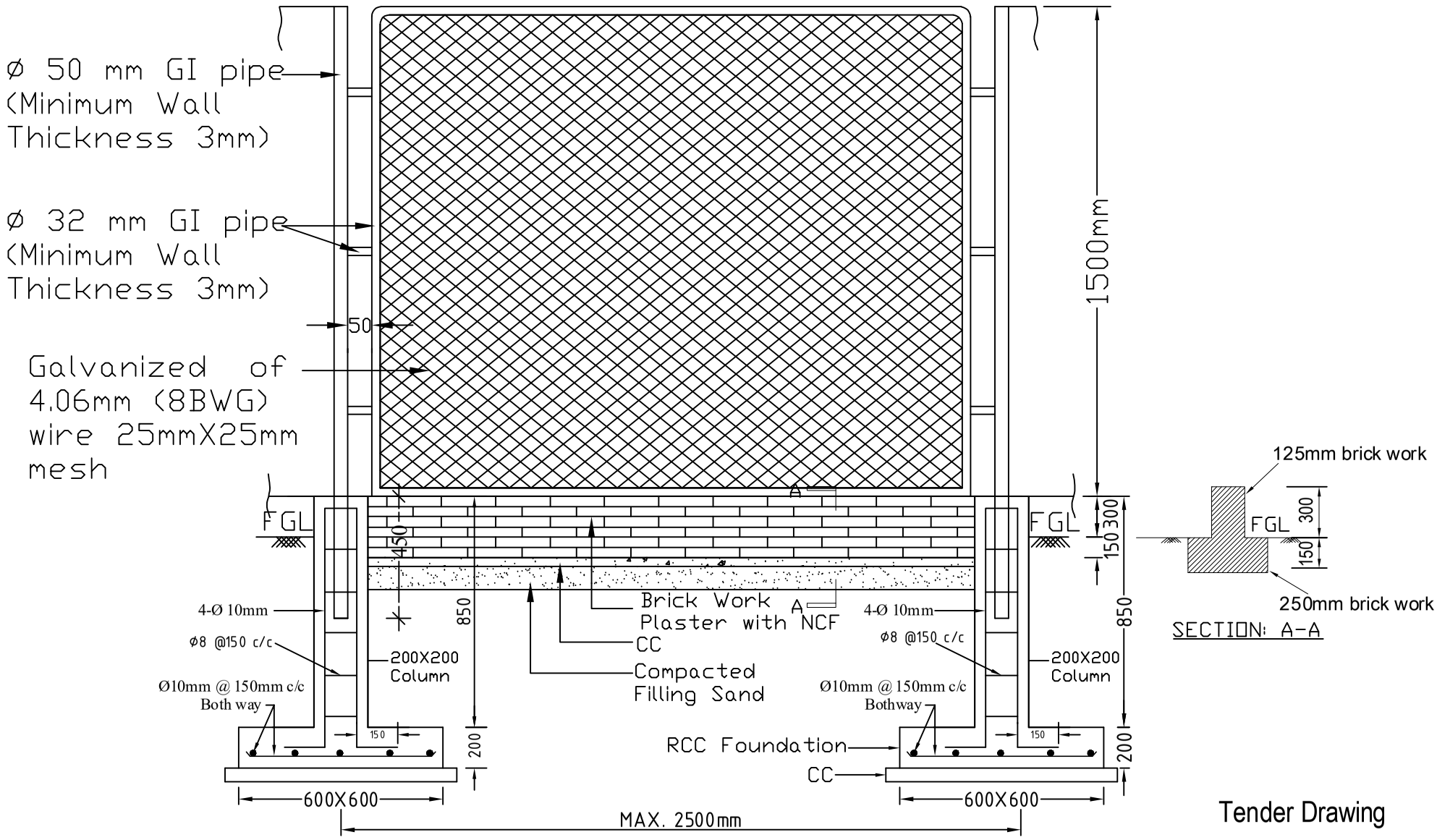

SIEMENS
400kV DIAMETER-3
CONTROL & TIE
PANEL-1
408CP1
DIA-3
BUS-1
FROM Unique
T1 - 750MVA
ATR-1
BUS-2


400kV DIAMETER-3
CONTROL & TIE
PANEL-2
408CP2
SIEMENS
SIPROTEC
DIA-4
T1 - 750MVA
ATR-1
BUS-2


=D1.Q07
+UHFN12
ABB
230kV Diameter -7 Control Panel
=D1.Q06
+UHKF1
DIA-07
Aminbazar-02 & SMPL-02
REC670
ABB
AMINBAZAR-02
BAY-201
BUS-1
BUS-2
GENERATING STN.
QC02


ABB
230kV Line-2 Aminbazar-S/S
=D1.Q06
+UHFN11
ABB
230kV
Panel
L-02
ABB
REL670
ABB
REL670
ABB
230kV

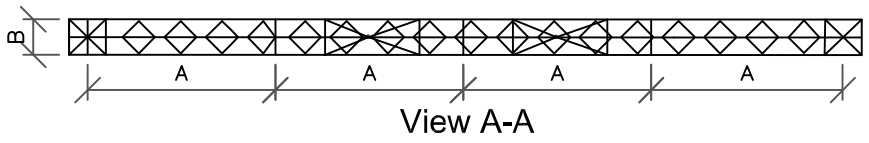

ABB
SAS PANEL-2
AF1+UHK2
ABB
SAS PANEL-1
=AF1+UHK1
ABB AFS670
DANGER
DO NOT OPERATE UNAUTHORISE PERSON
ABB
DANGER
DO NOT OPERATE UNAUTHORISE PERSON
ABB
ADVANTECH
SAS-2



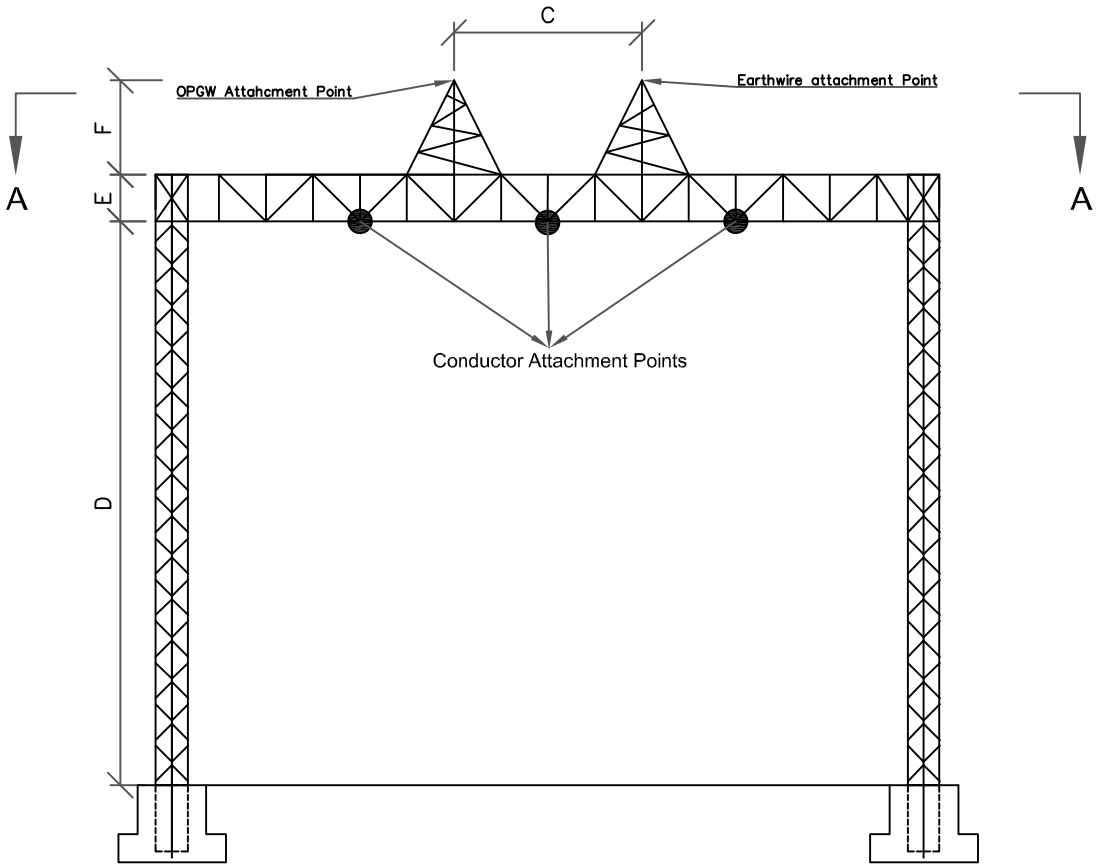
Typical Section of Chain Linked Fencing

Tender Drawing

Power Grid Company of Bangladesh Limited	
Project	Design, Supply, Installation, Testing & Commissioning of 400/230/33kv ATR and associated equipment in Meghnaghat 400/230 kV Substation on Turnkey Basis
Drawing Title	Typical Section of Chain linked fencing
Drawing No.	
Drawn:	Checked: Approved



View A-A



Dimension Mark	Maximum Allowable Value (mm)
A	4,000
B	1,500
C	4,000
D	13,500
E	1,500
F	2,000

NOTES:-

All dimensions are in mm

FOR TENDER PURPOSE ONLY

Drawn | Approved

PROJECT:

Design, Supply, Installation, Testing & Commissioning of 400/230/33kV ATR Along with Associated Equipment and 230kV Single Circuit Transmission Line in Meghnaghat 400/230kV Substation on Turnkey Basis.

DRAWING TITLE:

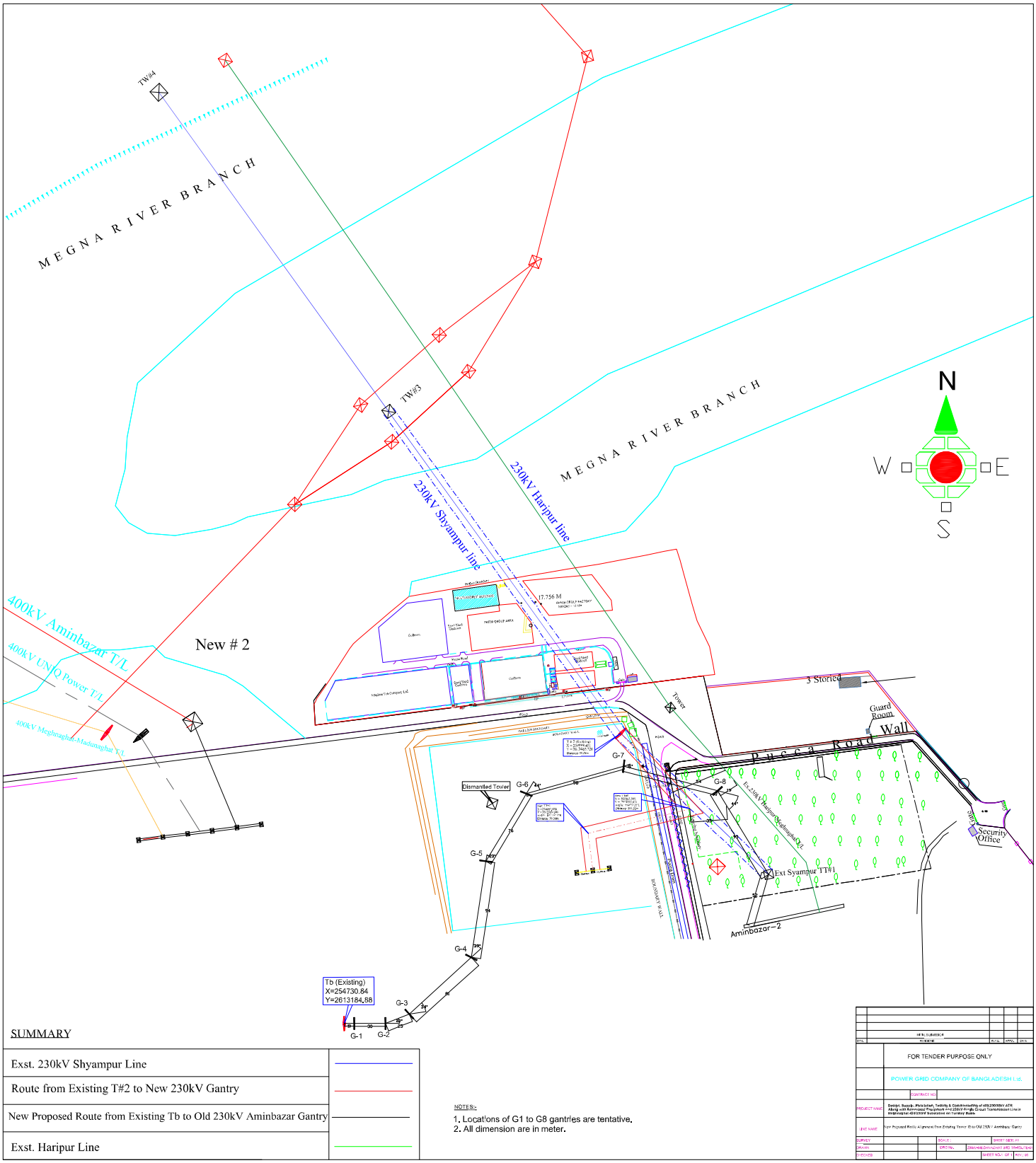
230 kV MEGHNAGHAT SUBSTATION 3RD TR GANTRY

Scale:	Drawn:	Checked:	Approved:	Size:
1:100				A0

DRAWING NUMBER:

PGCB/230kV/MEGHNAGHAT-3RD TR/ GCT

Rev: 0



SUMMARY

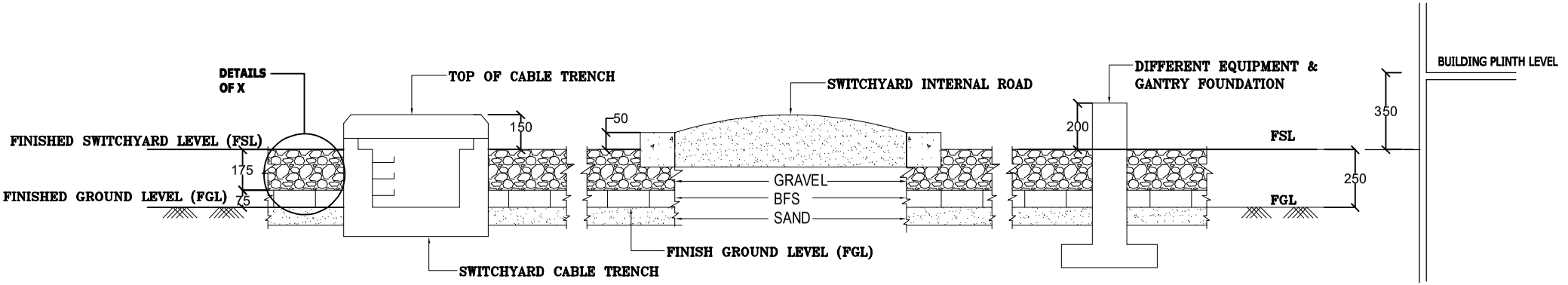
Exst. 230kV Shyampur Line	
Route from Existing T#2 to New 230kV Gantry	
New Proposed Route from Existing Tb to Old 230kV Aminbazar Gantry	
Exst. Haripur Line	

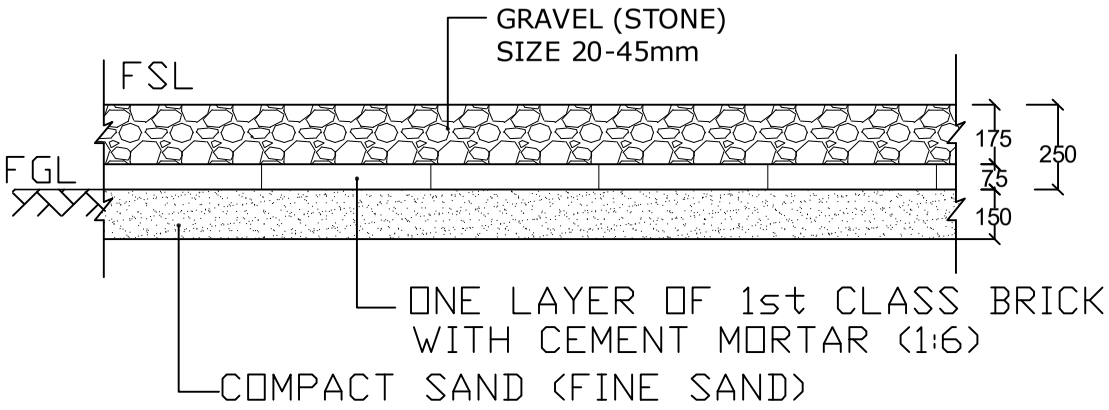
NOTES:-

1. Locations of G1 to G8 gantries are tentative.
2. All dimension are in meter.

FOR TENDER PURPOSE ONLY

POWER GRID COMPANY OF BANGLADESH Ltd.





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 Company of Bangladesh Limited	
Project	Design, Supply, Installation, Testing & Commissioning of 400/230/33kv ATR and associated equipment in Meghnaghat 400/230 kV Substation on Turnkey Basis
Drawing Title	Switchyard Gravelling and Relative Levels of Different Structures
Drawing No.	
Drawn:	Checked: Approved