POWER GRID COMPANY OF BANGLADESH LIMITED

Bidding Document

for

Design, Supply, Installation, Testing and Commissioning of 230 KV Indoor GIS Substation with 132 kV AIS at Faridpur and GIS Bay Extension of existing 230/132 kV Barisal (North) AIS Substation on turnkey basis.

Volume 2 of 3

SCOPE OF WORK

TECHNICAL SPECIFICATIONS

DRAWING FORMING PART OF SPECIFICATION

Issued on: 24 July 2018
Invitation for Bids No.: 27.21.0000.101.07.110.18.4726
ICB No.: PGCB/ADB/51137/230kV/SS/FARIDPUR
Employer: Power Grid Company of Bangladesh Ltd. (PGCB)
Country: The Peoples Republic of Bangladesh

SECTION 1

SCOPE OF WORK

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SECTION 1

SCOPE OF WORK

1.1 DESCRIPTION OF THIS BID

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

This Bidding Document is for the design, manufacture, quality assurance, new packing for export, insurance and shipment to site, complete construction and installation, jointing, terminating, bonding, earthing, painting, setting to work, site testing and commissioning, warranty for a period of 365 days for all equipment, including all civil works.

The detailed requirements are listed in schedule A and price schedule of volume 3 of these documents. The brief description of works under this contract is as follows:

Scope 1:New 230/132 kV Indoor GIS Substation at Faridpur

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

Design, supply, delivery, installation, testing & commissioning of a complete new 230/132 kV GIS substation adjacent to existing Faridpur 132/33 kV Grid substation under Faridpur District (which is situated at the south region of country and about 130 km away from the center of capital Dhaka).

- Complete 230 kV Indoor GIS consisting of two line bays, two transformer bays and one bus-coupler bay to connect two new 230 kV over head lines (Barisal-1 & 2) & two new 230/138/33kV transformers; space provision shall be kept for future extension of nine 230kV bays.

- 132 KV side of 230/138/33kV transformers shall be connected to 132 kV Busbar of existing Faridpur 132/33 kV Grid substation.

- Three (3) 132 kV AIS bay extension at existing Faridpur 132/33kV substation. two complete new 132kV Transformer bays equipment shall be installed to connect 132kV side of 230/138/33kV transformers and one complete new 132kV Transformer bay equipment shall be installed for future capacity up gradation.Space provision shall be kept for future extension of five (5) 132kV bays. Existing bus shall be extended for connecting new 132 kV bays.

- Design, supply, delivery, installation, testing & commissioning of two 250/350 MVA, 230/132/33 kV outdoor type auto transformers and two 33/0.4 kV, 300KVA outdoor type earthing transformers.

- Outdoor type 36kV VCB with CT, PT,LA, DS for 33kV side of earthing transformer to connect with tertiary side of Auto transformer.

Associated control, protection, substation automation, fiber optic multiplexer equipment for communication & protection, DFDR and civil works including GIS building are also under scope of work of this turnkey bid. space provision shall be kept for future extension in 230kV GIS room.

Major Contract components:

i) Power transformers,
ii) 230 KV Gas Insulated Switchgears (GIS),
iii) 132kV AIS switchgear (Circuit Breaker, Disconnector, Current Transformer, Voltage Transformer, Surge Arrester etc)

iv) Vacuum Circuit breaker,
v) Earthing transformers,
vi) Surge arresters
vii) Relays and Substation automation system as well as metering system
viii) Fiber Optic Multiplexer Equipment for Protection and Communication
ix) Digital Fault and Disturbance Recorder (DFDR)
x) Underground XLPE power cables and termination kits
xi) LVAC and DC Auxiliary system,

Details Scope of Supply of the Plant and Services are specified in Volume 3 of 3 of the Bidding Document.

Scope 2: Bay extension of existing 230/132 KV AIS SUBSTATION at Barisal (North)

The scope of work under this turnkey Bid is design, supply, delivery, installation, testing and commissioning for extension of two (2) new 230kV Gas Insulated Switchgear (GIS) Line bays at existing Barisal 230/132kV substation (Which is situated at the South side and about 300 km away from the main Dhaka city) with associated control, protection, fiber optic multiplexer equipment for communication & protection, and associated civil works.

Major Contract components:

i) Extension of 230kVGas Insulated Switchgears (GIS),

ii) Surge Arresters
iii) Relays and extension of Substation automation system,
iv) Extension of Fibre Optic Multiplexer Equipment for Protection and Communication,
v) Underground XLPE power cables.
vi) Civil Works and Foundation.

vii) NLDC Integration for SCADA system, Telecontrol and Telemetering facilities for new bays.

Detail Scope of Supply of the Plant and Services are specified in Volume 3 of 3 of the Bidding Document.

The “Schedule of Requirements” for equipment, materials and services and the Detailed Technical Specifications of equipment and materials as included in Volume 3 of 3 of the Bidding Document shall be read in conjunction with the scope of work described herein. The drawings provided in the Bidding Document are indicative only and hence the entire scope of work is not fully reflected in those drawings.

The Programme of Works shall be as shown in Schedule C of Times for Delivery and Completion. Within one month of the signing of the Contract, the Contractor shall submit a programme chart detailing times required for the design, manufacture, testing, delivery and erection for the complete contract.

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

Training and Witness:

(1) Factory Acceptance Test (FAT) Witness:

The contract price shall include all costs of witnessing of factory acceptance tests by Employer's engineer. Total three (3) nos. of visit for witnessing of factory acceptance tests by Employer's engineer (two engineers in each visit, and seven days for each visit excluding travelling time) is required for the following equipment’s:

(i) One visit for 230/132 kV power transformers

(ii) One visit for 230 kV GIS

(iii) One visit for SAS, Control & protection equipment

The Contractor shall be responsible for bearing all costs for the Employer’s engineers, including air fares, accommodation, meal, healthcare, laundry, transportation, visa fees etc. together with payment of a daily allowance of US$ 100 for each of the Employer's engineer.

(2) Training:

The contract price shall include all costs of foreign and local training for Employer's engineer.

Local Training:

The Contractor shall be responsible for providing instruction and guidance to PGCB personnel in the operation and maintenance of the substation equipment. During the installation the Contractor should provide minimum one trainer (authorised by the manufacturer) for training of Employer's personnel on site for minimum one week for training of Substation operation & maintenance and for one week for training of substation automation, control & protection system so that they could get a clear idea about operation, inspection/maintenance of the equipment. The number of trainee for Training shall be 15(fifteen) in the Training program. The contractor shall be responsible for providing lunch and training material to the trainee.

TERMINAL POINTS

1) 230 kV AND 132 kV Overhead Line Circuit Connections

The slack spans including overhead earth wires between the 230 kV terminal tower and the substation gantry structures shall be supplied and terminated by the overhead line contractors. All required insulators and hardware's shall also be supplied by the overhead line contractor.

Eyebolts/U-bolts or other suitable fixtures for terminating the slack spans on the switchyard gantry shall be provided under the substation Contract (Contractor under this Contract).

The substation Contractor (Contractor under this Contract) shall provide all the jumpers from the slack span to the substation equipment on the substation entry equipment by fixing appropriate T-terminals on the slack span conductor or other approved means. The supply of appropriate clamps and the actual termination of the jumper to the substation equipment shall be carried out under this Contract.

Bonding of the incoming earth wire to the station earthing screen and supply of earthing conductor and connection of the terminal tower earth electrode into the substation earth grid shall be carried out under this Contract.

The overhead line Contractor shall terminate the OPGW at the substation gantry in the terminal joint boxes provided by the overhead line Contractor.

The connection between OPGW joint boxes at Substation gantry and control room building via underground optical fibre cables shall be carried out under this Contract which includes supply & installation of fibre optic cable of size similar to OPGW.

2) Communications and SCADA Equipment

The voice communication, teleprotection signalling and main distribution frame (MDF) for optical fibre cable will be supplied and installed under this Contract. Necessary equipment for incorporating new 230 kV & 132 kV system into the existing SCADA system shall also be supplied and installed under this Contract

In order to provide the telecontrol & telemetering (SCADA) facilities required at the existing National Load Despatch Center (NLDC) at Aftabnagar, and also back up NLDC at Biddut Bhaban, Dhaka; all plant supplied under this Contract shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals. All required electrical signals shall be transmitted to the NLDC through the Industrial Gateway of the substation automation system. All HV breakers, motorized disconnectors, tap changer, etc. shall be controlled form NLDC through the Gateway of the substation automation system using IEC 60870-5- 104 protocol. Necessary transducer, control & interposing relays, RTU's, etc. shall be used. Necessary interfacing between the Substation Automation gateway and the communication equipment is to be carried out.

In addition, to realize the complete SCADA system after completion of the Project, modification of the existing software in the master computer of the national load despatch centre, and modification of hardware (installing additional printed circuit cards etc. if required) shall be made under this Contract.

1.2 SYSTEM ELECTRICAL PARAMETERS

1.2.1 System Conditions

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

Nominal system voltage between phases	kV	230	132	33
System frequency	Hz		50	
Rated voltage between phases	kV	245	145	36
Lightning impulse withstand	kV	1050	650	170
50 Hz withstand 1 minute	kV	460	275	70
Symmetrical short-circuit current (3 sec)	kA	40	40	31.5

1.2.2 System Earthing

The 230/132/33kV auto transformers are solidly earthed.

The 230kV system and 132kV system is solidly earthed at the power transformer 132 kV neutrals and 230/132/33 kV auto transformer neutrals but not earthed at the Grid supply points.

The 33 kV system is solidly earthed at some of the 132/33 kV grid substations and resistance earthed at some of the grid substations.

1.2.3 Minimum Substation Clearances

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

Nominal system voltage	kV	230	132	33
Minimum clearance between live metal and earth	mm	2100	1300	380
Minimum clearance between live metal	mm	2400	1500	430
Minimum safety clearance between ground and the nearest point not at earth potential of an insulator	mm	2500	2500	2500

Minimum safety clearance between ground and the nearest live unscreened conductor (BS 7354 'Safety Working Clearance')	mm	4270	3500	2740
Minimum insulator creepage distance (at rated voltage between phases)	mm/kV	25	25	25

1.2.4 Low Voltage AC System

Rated service voltage (3 phase, 4 wire 50 Hz)	415/230 volts
Tolerance on rated voltage	+15%, -15%
Switchgear symmetrical breaking capacity	15 kA, 3 sec
System earthing	Solid

1.2.5 D.C. System

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

Nominal DC voltage	110 V nominal
Tolerance on rated voltage	+ 10%, -10%

For telecommunication & future SCADA	
Nominal DC voltage	48 V nominal
Tolerance on rated voltage	+ 10%, -10%

1.3 CLIMATIC CONDITIONS

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

The project area and vicinity is close to sea level and is in a tropical climate. The ambient shade temperature variation is between 4^0C and 45^0C with periods of high humidity.

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

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

The project area is designated a zone of moderate intensity for earthquakes. The seismic factor is 0.1 g.

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

Maximum ambient shade temperature	45^0C
Minimum ambient shade temperature	4^0C
Maximum daily average temperature	35^0C
Maximum annual average temperature	25^0C

Maximum wind velocity	160 Km/h
Minimum wind velocity for line rating purposes	3.2 Km/h (132, 230 kV)
Solar radiation	100 mW/sq.cm
Rainfall	2.5 m/annum
Relative humidity, maximum	100%
Relative humidity, average	80%
Altitude	less than 150 m
Atmospheric Pollution	light
(No ice or snow expected)	
Soil type	alluvial
Soil temperature (at 1.1m)	30^0C
Soil thermal resistivity	1.5^0C m/W
Isokeraunic Level (Thunderstorm days/year)	80

SECTION 2

ANCILLARY MECHANICAL AND ELECTRICAL APPARATUS

TABLE OF CLAUSES

SECTION 2

ANCILLARY MECHANICAL AND ELECTRICAL APPARATUS

2.1 SCOPE

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

2.2 REFERENCES

2.2.1 ISO Standards

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

2.2.2 IEC Standards

60034-1	Rotating Electrical Machines - Part 1: Rating and Performance
60038	IEC Standard Voltages
60051	Direct acting indicating analogue electrical measuring instruments and their accessories
60055	Paper insulated metal sheathed cables up to 18/30 kV
60059	IEC Standard Current Ratings
60072	Dimensions and output series for rotating electrical machines
60073	Coding principles for indicators and actuators
60079	Electrical apparatus for explosive gas atmospheres
60085	Thermal evaluation and designation of electrical insulation
60099-4	Metal-oxide surge arresters without gaps for a.c systems
60137	Bushings for alternating voltages above 1000 V
60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
60228	Conductors of insulated cables
60269	Low voltage fuses
60273	Characteristics of indoor & outdoor post insulators for systems with nomial

	voltages greater than 1000 V
60282	High voltage fuses
60296	Unused mineral insulating oils for transformers & switchgear
60305	Characteristics of string insulator units of the cap & pin type
60332	Tests on electric and optical fibre cables under fire conditions
60364	Electrical installations of buildings
60376	Specification and acceptance of new sulphur hexafluoride
60383	Insulators for overhead lines with a nominal voltage above 1000 V
60417	Graphical symbols for use on equipment
60423	Conduits systems for cable management
60433	Characteristics of string insulator units of the long rod type
60437	Radio interference test on high voltage insulators
60439	Low voltage switchgear and controlgear assemblies
604552-2	Solventless polymersable resinous compounds used for electrical insulation
60480	Guideline for the checking of sulphur hexafluoride taken from electrical equipment
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
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 & controlgear-General rules
60947-2	Circuit breakers
60947-3	Switches, disconnectors, switch-disconnectors, etc.
60947-5-1	Control circuit devices and switching elements
60981	Extra heavy duty electrical rigid steel conduits
61035	Specification for conduit fittings for electrical installations
61084	Cable trunking & ducting systems for electrical installations
62271-1	Common clauses for HV switchgear & control gear standards
62271-100	High voltage alternating circuit breakers
62271-200	AC metal - enclosed switchgear & control gear for 1 kV and up to including 52 kV
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

BS29	Spec for Carbon steel forgings
BS 182	Specification for galvanised line wire for telephone & telegraphic purposes
BS 443	Specification for testing zinc coatings on steel wire
BS499	Welding terms & Symbols
BS709	Method & testing fusion welded joints
BS 729	Specification for hot dip galvanised coatings on iron & steel articles
BS970	Specification for wrought steels for mechanical & allied engineering
BS CP 1014	Tropicalisation

BS 1224	Specification for electroplate coatings of nickel and chromium
BS1710	Specification for identification of pipelines & services
BS 1780	Specification for Bordon tube pressure and vacuum gauges
BS 1858	Specification for bitumen based filling compounds
BS 2011	Environmental Testing
BS 2569 Pt2	Protection of iron & steel against corrosion at elevated temp.
BS 2600 Pt 1	Radiographic examination of fusion welded butt joints in steel
BS 2765	Specification for dimensions of temperature detecting elements
BS 2910	Radiographic examination of fusion welded circumferential butt joints
BS 3858	Specification for sleeves for electric cables & wires
BS3923 Pt1 &Pt2	Methods of examination of fused welds and butt joints.
BS 4211	Specification for ladders for permanent access to chimneys, other high structures, silos and bins
BS4395-1-2	Specification for High Strength Grip Bolts
BS4479 Pts 1-9	Recommendations for coatings.
BS 4592 Pt 1-4	Industrial type flooring, walkways and stair treads
BS4604 Pt 1-2	Spec for high strength friction bolts
BS4670	Spec for alloy steel forgings.
BS 4800	Schedule of Paint Colours for building
BS 4675 Pt2	(ISO 2954) Mechanical vibration of rotating and reciprocating machinery
BS 4872 Pt 1	Fusion welding of steel
BS 5395-3	Code of Practice for the design of industrial type stairs, permanent ladders etc.
BS 5493	Code of practice for protective coating of iron & steel structures against corrosion
BS6072	Method for penetrant flaw detection
BS 6121-1	Specification for metallic cable glands
BS 6121-2	Specification for polymeric cable glands
BS 6121-3	Specification for special corrosion resistant cable glands
BS 6180	Code of Practice for barriers in and about buildings
BS 6231	Specification for PVC insulated cables for switch & control wiring
BS6443	Method of penetrant flaw detection.
BS7079	Preparation of steel substrates before application of paints

2.2.4 BS European Standards

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

2.3 DEFINITION OF TERMS

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

2.4 STATUTORY REGULATIONS

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

2.5 DESIGN STANDARDS AND CODES

2.5.1 General Compliance with International Standards and Codes

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

2.5.2 Standards Named in Specification

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

2.5.3 Hierarchy of Standards

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

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

Where equipment is specified to a particular standard, the 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 which comply with international standards, or internationally-recognized 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 organization 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 which differ from those specified shall declare the fact to the Engineer. If requested to do so by the Engineer, the Contractor shall supply to the Engineer, at his own cost, two copies in English of the relevant code or standard which he proposes to substitute for that specified.

2.6 ERECTION MARKS

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

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

2.7 CLEANING AND PAINTING

2.7.1 General

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

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

The 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 which occurs during transport shall be made good at Site.

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

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

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

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

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

The Engineer will consider alternative paint schemes to meet the requirements of fabrication using modern automated materials handling systems, provided that the 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 employed does not produce paint films containing vacuoles.

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

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

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

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

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

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

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

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

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

All outdoor painting shall be checked prior to issue of the final certificate and no visible corrosion or spotting shall be present. Slight loss of gloss may acceptable. In the event of visible corrosion being present, the Employer will retain the right to withhold such an amount from the 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 recommendations of the Standards and Codes of Practice referred to and the paint manufacturer's special instructions where applicable, colours being in accordance with BS 1710 and BS 4800, or equivalent material standards.

2.7.2 Schedules of Finishes

2.7.2.1 Schedules for Indoor Surfaces

2.7.2.1.1 General

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

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

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

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

(c) Galvanized iron and steel requiring paint finish

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

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

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

(e) Bitumen dipped items

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

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

(a) Steelwork

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

2.7.2.1.3 Bright Parts

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

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

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

2.7.2.2 Schedules for Outdoor Surfaces

2.7.2.2.1 General

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

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

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

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

(c) Galvanized iron and steel requiring paint finish

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

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

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

(e) Bitumen dipped items

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

2.7.2.2.2 Bright Parts

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

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

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

2.7.2.2.4 Water and Oil Storage Tanks - Internal Surfaces

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

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

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

2.7.2.3 Radiators

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

2.8 RATING PLATES, NAMEPLATES AND LABELS

2.8.1 General

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

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

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

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

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

All equipment within panels and desks shall be individually identified.

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

2.8.2 Rating Plates

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

2.8.3 Circuit Labels

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

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

2.8.4 Pipe Service Identification

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

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

Valve labels shall be circular and fitted under the handwheel captive nut. For check valves and small valves the 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 secured arrow, showing the direction of flow.

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

2.9 ENVIRONMENTAL PROTECTION & TROPICALISATION

2.9.1 General

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

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

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

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

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

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

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

2.9.2 Tropicalisation

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

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

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

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

2.10 PLATFORMS, STAIRWAYS, LADDERS AND HAND-RAILING

2.10.1 General

The 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 workmen, tools and portions of plant which may be placed on them during overhaul and inspection periods.

Galleries, platforms and stairways shall be designed generally for a load of 7.5kN/m^2 but where loads in excess of this are likely to be imposed during operation or maintenance, the 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 Contract.

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

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

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

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

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

2.10.2 Flooring

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

Toe plates extending to a height of not less than 100 mm above the platform or gallery level and of a thickness of not less than 6 mm shall be supplied. Any opening which it is necessary to cut in the open grid flooring or chequer plate shall be finished off with an edging strip similar to that on the floor panels.

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

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

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

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

2.10.3 Hand-railing and Protective Barriers

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

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

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

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

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

2.10.4 Stairways

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

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

2.10.5 Fixed Access Ladders

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

2.11 NUTS, BOLTS, STUDS AND WASHERS

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

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

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

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

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

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

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

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

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

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

2.12 FORGINGS

The 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 surface 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 which shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates relative to the forging.

2.13 CASTINGS

2.13.1 General

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

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

2.13.2 Steel Castings

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

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

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

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

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

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

The Engineer may require that certain castings be examined using radiographic techniques. The 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 impact, or to a working temperature exceeding 200˚C, unless specifically approved by the Engineer. Nor shall it be used for chambers of oil filled apparatus.

Weldable grades of iron castings may be repaired by welding provided the approval of the Engineer is first obtained. The 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 eventuality 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 document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the specifications shall be issued to the Engineer for his use.

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

Weldable grades of aluminium bronze may be repaired by welding, provided the written approval of the Engineer is first obtained. The 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

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

2.14 GENERAL WELDING REQUIREMENTS

2.14.1 General

All welding shall conform to the relevant British Standards, or other British or National Standard Specification as agreed by the Engineer.

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

2.14.2 General Fabrication

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

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

2.14.3 Weld Procedure Documents

Complete and fully detailed weld procedure documents shall be kept by the 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 relevant sections of work.

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

2.14.4 Weld Procedure Qualification Tests

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

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

The 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' qualification certificates in accordance with BS EN 287, BS 4872 or agreed National Standard for the work.

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

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

2.14.6 Storage of Welding Consumables

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

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

2.14.7 Welding Equipment

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

2.14.8 Visual Weld Inspection

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

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

2.14.9 Internal Examination

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

2.14.10 Non-destructive Examination

All non-destructive examinations shall be supervised by a fully qualified and experienced specialist appointed by the 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 P art 1 Part 2 and any other relevant British Standards or agreed National Standards.

2.14.12 Magnetic Crack Detection

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

2.14.13 Dye Penetrant Tests

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

2.14.14 Quality Requirements for Welds

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

2.14.15 Weld Repairs

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

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

2.14.16 Mandatory Inspections

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

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

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

2.15 GALVANISED WORK

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

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

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

Galvanised wire shall comply with the requirements of BS 182 and the thickness of the coating and testing thereof shall comply with BS 443. Nuts and bolts and small

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

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

Should an emergency arise on Site necessitating drilling, cutting or any other process likely to damage the protective zinc surface, this will be permitted only in extreme circumstances and with the Engineer's express authority. In such a case, the bared metal will be coated with an approved zinc rich paint of not less than 92 percent zinc content.

2.16 CHROMIUM PLATING

The chromium plating of those components of the Plant where specified and where offered by the 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, ie. horizontal split-casing types for large centrifugal pumps and horizontal, back pull-out types for smaller units. Where a significant saving in floor space or improvement of layout can be shown, a vertical pump may be acceptable.

Pumps shall be capable of continuous operation with minimum maintenance.

2.18 PIPEWORK

2.18.1 General

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

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

2.18.2 Internal cleaning of pipes

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

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

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

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

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

2.18.3 Pipe Supports and Anchors

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

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

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

2.19 VALVES

2.19.1 General

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

2.19.2 Hand Operation Requirements

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

All valves shall be closed by rotating the handwheels in a clockwise direction when looking at the face of the handwheel. In cases where the handwheel is not directly attached to the valve spindle suitable gearing shall be introduced to ensure clockwise closing. The face of each handwheel shall be clearly marked "open" and "shut" or "closed" with arrows indicating the direction of rotation to which they refer.

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

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

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

2.20 PRESSURE VESSELS

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

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

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

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

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

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

Should any difficulty arise in the decision as to whether a particular vessel shall comply with a pressure vessel code, the vessel shall be "coded" unless specifically excluded in clause U- 1 of the US ASME Boiler and Pressure Code, Section VIII, division 1, dealing with the scope of that code.

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

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

2.21 LUBRICATION

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

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

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

2.22 OIL LEVEL INDICATORS

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

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

2.23 PRESSURE GAUGES

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

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

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

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

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

2.24 THERMOMETER POCKETS

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

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

2.25 GAUGE CUBICLES AND PANELS

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

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

2.26 LOCKING FACILITIES

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

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

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

(c) Isolating valves in open or closed positions.

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

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

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

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

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

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

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

2.27 ELECTRICAL EQUIPMENT

2.27.1 General

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

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

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

Corresponding parts of similar equipment, and equipment liable to renewal, shall be fully interchangeable and the 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 61000.

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

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

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

2.27.2 Electrical Equipment Enclosures

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

(a)	Indoors only in totally enclosed rooms with provision for limiting ingress of dust:	IP 31
(b)	Indoors, except as noted otherwise:	IP 54
(c)	Outdoors, and indoors in areas subject to water spray, or heavy condensation:	IP55W

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

2.28 CURRENT RATINGS

2.28.1 Normal Current Ratings

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

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

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

2.28.2 Temperature Rise

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

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

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

In such cases where the 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 derated to suit the site conditions and any changes required by the Engineer shall be made at no extra cost.

2.28.3 Short-time Current Ratings

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

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

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

2.29 VOLTAGE RATINGS

2.29.1 Normal Voltage Ratings

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

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

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

2.29.2 Short-time Voltage Ratings

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

2.30 ELECTRICAL INSULATION

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

Ebonite, synthetic resin-bonded laminated material and bituminised asbestos cement-bonded panels shall be of suitable quality selected from the grades or types in the appropriate IEC, or approved National Standard.

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

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

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

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

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

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

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

2.31 INSULATING OIL

Insulating oil shall comply with the requirements of IEC 60296. Insulating oil shall be provided by the 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 require for his own use in order to ensure that insulating oil meets the requirements of the specification.

2.32 CONTROL AND SELECTOR SWITCHES

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

Circuit breakers shall have control switches which shall be labelled open/N/close or (O/N/I) and arranged to operate clockwise when closing the circuit breakers and anti-clockwise when opening them.

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

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

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

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

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

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

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

2.33 PANELS, DESKS AND CUBICLES

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

Panels shall be rigidly constructed from folded sheet steel of 3mm minimum thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess.

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

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

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

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

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

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

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

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

Each panel shall include rear access doors internal power sockets and door-operated internal lighting, and be clearly labelled with the circuit title at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltages higher than 125V (nominal) shall be partitioned off and the voltage clearly labelled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

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

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

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

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

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

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

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

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

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

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

2.34 INSTRUMENTS & METERS

2.34.1 Indicating Instruments

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

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

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

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

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

2.34.2 Electrical Meters

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

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

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

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

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

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

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

2.35 INDICATING LAMPS AND FITTINGS

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

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

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

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

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

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

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

Red - energised or operative position

Green - de-energised or inoperative position

Amber - fault or abnormal condition

White - healthy or normal condition

Blue - other purposes, to be used with descriptive label

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

Indication circuits shall be fused.

2.36 ANTI-CONDENSATION HEATERS

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

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

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

2.37 CONTROL AND INSTRUMENT PANEL WIRING, 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:

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

(b) Class 2 conductors except where specified otherwise,

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

The following minimum conductor sizes shall be used:

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

(b) 1.5 mm2 except where specified otherwise,

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

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

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

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

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

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

If so required, the 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 associated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colours, except when an automatic or proprietary system of wiring is used, e.g. point-to-point wiring on a mother board.

When a wire numbering system is used, it should be in accordance with a functional marking system. Both ends of every wire and core in control and instrument cables shall be fitted with interlocking ring ferrules of white insulating material indelibly marked with black characters, complying with BS 3858. Heat shrink marking sleeves may be used, but adhesive markers are not acceptable.

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

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

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

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

2.37.3 Terminals and Terminal Blocks

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

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

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

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

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

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

Terminal boards shall be mounted vertically, not less than 150mm above the gland plates, and spaced not less than 100mm apart, on the side of the enclosure and set obliquely towards the rear doors.

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

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

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

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

The 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 Engineer'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 elsewhere.

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

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

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

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

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

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

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

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

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

The 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 500A, adequate steps must be taken to minimise the effects of eddy currents in the gland and bushing-mounted plate.

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

2.38.2 Additional Requirements for Compound-filled Cable Boxes

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

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

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

2.38.3 Cable Glands

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

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

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

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

Under conditions of severe corrosion, corrosion-resistant cable glands complying with BS 6121 Part 3 may be used, or the 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 unarmoured cables.

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

2.39 BOX-FILLING COMPOUNDS

The type of compound shall be to the approval of the Engineer, who shall be supplied with sufficient information by the Contractor. The Contractor shall supply all compound required together with an additional quantity of not less than 10% of normal requirements.

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

The 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 which have to be broken, shall be welded and care shall be taken to ensure that the chambers are oil-tight. Defective welded joints shall not be repaired but maybe re-welded subject to the written approval of the Engineer.

Insulating compound shall comply with BS 1858.

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

2.41 JOINTS AND GASKETS

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

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

2.42 VALVES ON ELECTRICAL EQUIPMENT FLUID LINES AND VESSELS

Valves shall comply with the requirements of Clause 2.19.

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

2.43 JUNCTION AND MARSHALLING BOXES

Junction and marshalling boxes for use in non-hazardous areas shall be of substantial sheet aluminium anodised coating construction to prevent corrosion, having an enclosure classification in accordance with the requirements of clause 2.27.2. They shall be fitted with external fixing lugs and finished in accordance with the requirements of the specification for cleaning, painting and finishing. The boxes shall allow ample room for wiring, with particular regard to the routing of wires from the point of entry. Boxes made from aluminium shall be subject to agreement with the Engineer.

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

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

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

All necessary gland plates shall be provided undrilled.

Boxes shall be complete with suitably inscribed identification labels.

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

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

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

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

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

2.44 CONDUIT AND ACCESSORIES

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

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

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

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

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

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

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

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

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

2.45 TRUNKING

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

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

2.46 ELECTRIC MOTORS

2.46.1 General

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

2.46.2 Type and Rating

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

Motors shall be continuously rated, Duty Type S1. Exceptions shall be permitted only when the intermittent or short time duty cycle can be accurately defined by the 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 34-1. The maximum rated output of LV motors shall not exceed 150 kW, except where approved by the Engineer.

2.46.3 Insulation

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

2.46.4 Conditions of Operation

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

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

2.46.5 Starting Performance

Unless otherwise specified or required, cage induction motors up to and including

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

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

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

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

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

2.46.6 Bearings

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

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

Bearings shall comply with the applicable ISO standards.

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

2.46.7 Enclosures and Methods of Cooling

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

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

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

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

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

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

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

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

2.46.8 Anti-condensation Heaters

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

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

2.46.9 Terminals and Terminal Boxes

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

(a) Main (line) connections.

(b) Star point connections.

(c) Anti-condensation heater connections.

(d) Instrumentation and alarm devices.

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

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

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

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

Porcelain terminal bushings and insulators shall not be used.

Main and star point terminal boxes of HV motors shall be of steel. Cast iron may only be used for LV motor terminal boxes and auxiliary terminal boxes.

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

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

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

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

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

2.46.10 Earth Terminal

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

2.46.11 D.C. Motors

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

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

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

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

2.47 MOTOR STARTERS AND CONTACTORS FOR SEPARATE MOUNTING

In special cases for motors below 30 kW, and non-essential non-plant auxiliaries, such as roller shutter doors, and where approved by the Engineer, separately mounted starters for motors may be provided. Each such motor starter shall be equipped with two or three pole control gear, as appropriate, for direct-on-line starting and shall be complete with a fully shrouded lockable isolating switch, mechanically interlocked with the means of access.

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

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

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

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

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

2.48 PUSHBUTTONS AND SEPARATELY MOUNTED PUSHBUTTON STATIONS

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

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

The colour of pushbuttons shall be as follows:

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

- When mounted on the front of the contactor panel the stop button shall be coloured red and the start button coloured green.

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

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

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

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

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

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

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

2.49 MINIATURE CIRCUIT BREAKERS, FUSES AND LINKS

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

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

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

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

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

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

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

2.50 EARTHING AND BONDING

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

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

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

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

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

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

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

The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus shall be such as to comply with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall be a minimum of 100 mm2 cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and also providing this size is not less than the size of the largest incoming power supply conductor.

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

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

SECTION 3A

HIGH VOLTAGE GAS INSULATED SWITCHGEAR

TABLE OF CLAUSES

SECTION 3

230 KV GAS INSULATED SWITCHGEAR

3.1 SCOPE

These clauses describe the General Technical Requirements for the new 230kV GIS switchgear equipment, 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 accordance with the relevant international standards and the specification. It shall also operate and perform on a site in accordance with the requirements of the specification and in the environment defined therein.

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

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

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

3.2 APPLICABLE STANDARDS

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

LIST OF STANDARDS

IEC 62271-1	Common clauses for high voltage switchgear and control gear standards
IEC 62271-100	High voltage alternating circuit breakers
IEC 62271-102	Alternating current disconnectors (isolators) and earthing switches
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 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IEC 62271-203	Gas insulated metal-enclosed switchgear for rated voltages 52 kV and above
IEC 62271-209	Cable connections for gas insulated metal - enclosed switchgear for rated voltages of 52 kV and above
BS 7354	Design of high voltage open terminal stations
IEC 60376	Specification and acceptance of new sulphur hexafluoride
IEC 60358	Coupling capacitors and capacitor dividers
IEC 60364	Electrical installation of buildings

	(Part-1: Scope, object and fundamental principles)
IEC 60364	Electrical installation of buildings (Part-2: Definitions- Chapter 21: Guide to general items)
IEC 60364	Electrical installation of buildings (Part-4: Protection for safety-Chapter 41: Protection against electric shock)
IEC 60071	Insulation co-ordination (Part-1: Definition, principles and rules, Part-2: Application guide)
IEC 60815	Guide for the selection of insulators in respect of polluted conditions
IEC 60137	Bushings for alternating voltages
IEC 60099-4	Metal - Oxide surge arresters without gaps for a.c. systems
IEC 60044-1	Instrument transformers, Part-1: Current Transformers
IEC 60044-2	Instrument transformers, Part-2: Voltage Transformers
IEC 60282	High voltage fuses.
IEC 60269	Low voltage fuses.
IEC 60865-1	Short-circuit currents – Calculation of effects (Part-1: Definitions and calculation methods)
IEC 61639	Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above

3.3 DESIGN CRITERIA

The GIS shall be designed to ensure satisfactory operation under the site and system operating conditions as per design criteria described in Section-1 Volume 2 of 3 of this Bidding Document.

3.4 TECHNICAL REQUIREMENTS

General design, material and manufacturing techniques used shall generally conform to General Technical Requirements.

3.5 QUALITY ASSURANCE

Manufacturers of 230 kV GIS shall certify on their compliance to ISO 9001:2008 by an organization authorized for certification.

3.6 DETAILED RATINGS

Switchgear and substation equipment shall be suitable for continuous operation on a 3-phase, 50 Hz system of 230 kV nominal voltage as per "Design Criteria" and under the climatic conditions specified. The 230 kV system is effectively earthed (at present).

The detailed ratings of 230 kV GIS shall be as stated in the Employer's Requirem ents, Schedule T3 in Volume 3.

3.7 TYPE OF SWITCHGEAR

The switchgear shall be of the SF6 gas insulated metal-enclosed type capable of continuous operation under the climatic conditions existing at the Site. Duplicate busbar switchgear shall be provided. Busbar selector isolators as specified in the Schedules are required to facilitate the changeover of individual circuits from one busbar to the other with the circuit on load and a bus coupler closed. Test report on capability of on load bus transfer shall be submitted for PGCB's approval.

The arrangement of the switchgear shall be such that all units face in the same direction and particular emphasis is placed on the provision of adequate clearance between chambers and between adjacent bays to facilitate maintenance.

The design of the switchgear shall be such as to enable extensions to be added at either end with the minimum of disturbance to the installed equipment and with one busbar in service. Suitable arrangement shall be provided with the switchgear for H.V. test of future extension part to keep the outage of the existing switchgear to a minimum.

The design shall include all facilities necessary to enable the performance of the specified site checks and tests during precommissioning & commissioning tests and after any repair & maintenance. The Contractor shall state the test facilities provided and indicate any attachments or special equipment provided for this purpose.

3.8 DESIGN PRINCIPLES AND GENERAL REQUIREMENTS

3.8.1 General

The design and performance of the switchgear shall comply with this Specification and the latest revision of the relevant International electrotechnicaI Commission (IEC), if no other standards are specified. Deviations from these specifications and standards shall be stated in the appropriate Schedule.

The drawings issued with this Specification indicate possible switchroom layouts for 230 kV equipment.

The switchgear shall be supplied complete with all auxiliary equipment necessary for safe operation, routine and periodic maintenance and repairs with sufficient space between modules.

The normal operations will be effected from the System Control Centre. The bidder shall take into consideration the unmanned operation of the substation in his design.

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 annunciator.

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

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

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

Circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle.

In case of labels not visible when standing on the floor, additional name plate shall be fixed at a suitable location.

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

In the event of leakage from any compartment, equipment shall withstand rated voltage with SF6 at atmospheric pressure.

The insulation levels shall be able to withstand basic test voltages in accordance with the relevant standards for Synchronising Operation for Breakers.

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

Equipment foundation requirement details complete with floor and structure fixings consistent with the switchgear design offered are to be provided at an early stage in order for these to be incorporated in the civil works design.

3.8.2 Availability for Maintenance, Repair, Extensions, Testing

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

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

MRE Testing on/of 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.

3.8.3 Gas Compartments

The switchgear units and busbar systems shall be divided into several gas-filled compartments, sealed from each other by gas-tight partitions.

The various gas zones shall be further sub-divided when necessary to restrict any internal arcing damage, particularly within sections of busbars and to enable gas handling procedures to be completed with the minimum of delay. The partitions should confine any internal faults to a respective section of the switchgear.

The number of gas compartments shall be such as to limit the amount of switchgear which has to be isolated and taken out of service as a result of gas leakages, planned maintenance or internal faults.

Proposals for the partitioning of gas zones shall be clearly indicated on the drawings submitted with the tender. Partitioning on the GIS shall be clearly marked with yellow paint on the GIS. Gas volumes and duration of gas handling procedures shall also be indicated in the technical schedules. Each gas zone shall have its own gas monitoring, filling, degassing, regassing & gas sampling facility.

Total time for gas evacuation and filling of the largest chamber shall not exceed 10 hours.

Suitable arrangements shall be provided for the thermal expansion and contraction of the busbars and busbar chambers without detriment to the current carrying capacity or gas volume.

Devices shall be provided for each section of switchgear as appropriate to allow for pressure relief. All relief devices shall be located such that operation of the devices shall not endanger personnel working on the equipment or in the vicinity of the equipment.

These devices shall be arranged to give individual compartment alarms in the local control units and initiation of remote alarms. Each gas-filled chamber shall be fitted with static filters to absorb any moisture which may be present. In addition filters for removal of SF6 decomposition products shall be provided in Circuit Breaker compartments.

For circuits equipped with double cable isolation, provision shall be made to remove the gas from either cable chamber whilst maintaining the other cable in service. i.e. Gas monitoring of the chamber in service shall be maintained at all times.

In chambers equipped for 230 kV cable sealing ends a disconnecting link must be provided to allow easy isolation between the cable sealing end and the main connections. It must be possible to remove this link without removal/refitting of the main connections Alternatively the barrier should be designed for HVAC test of Power Cable.

In order to compensate for any small variations in floor level each compartment shall be fitted with means of adjustment (jacking screws or similar). Such adjustments shall be fully described in the maintenance manuals provided by the manufacturer. In case such arrangements do not exist, it shall be the responsibility of the manufacturer to ensure acceptable floor level tolerance.

Enclosures shall be clearly marked to identify gas compartment zones, disconnectors, circuit-breakers, earthing switches, current transformers, voltage transformers, surge arresters and other primary devices contained therein. The method proposed shall be subject to the approval of PGCB.

3.8.4 Gas Barrier and Supporting Insulators

Gas barriers shall be gas tight and of sufficient strength and factor of safety to withstand short circuit forces and the maximum pressure differential that can occur under internal fault conditions. The gas barrier withstand pressure shall be more than that of bursting disc. It should be possible to vacuum, any chamber with adjacent chambers having full pressure.

3.8.5 Enclosures

The enclosures for the SF6 gas insulated switchgear shall be of Aluminium Alloy.

It shall be capable of withstanding maximum differential pressure between adjacent gas zone over a considerable period. Evidence shall be provided to verify that enclosures have been designed and tested in accordance with established pressure vessel codes.

Each enclosure shall be tested and stamped by the inspecting authority issuing the test certificate.

Circuit-breakers, isolators, earth switches, VTs, CTs, surge arresters, cable termination chambers, all and any other chambers and components shall have pressure tests on enclosures as per IEC 62271-203 clause 7.101. The withstand pressure of the enclosures shall be well over the bursting disc operation pressure and shall be embossed on all the enclosures at a conspicuous location.

Voltages induced in the enclosures shall not be allowed to exceed reasonable safe limits. All chambers throughout the equipment shall be earthed at an approved number of points. All necessary earthing bars and associated fixings shall be provided. Approved GIS earthing drawings are to be supplied from the manufacturer of the GIS.

Each enclosure shall be provided with lifting points to facilitate maintenance or repair works.

3.8.6 SF6 Gas

3.8.6 (a) SF6 Gas Requirements

All SF6 gas supplied for use in the switchgear shall comply with the requirements of IEC 60376.

Test Reports shall be submitted for review.

3.8.6 (b) SF6 Immersed Insulation

Busbars and items of switchgear shall be supported in the enclosures by insulators of materials compatible with SF6 gas and the products of gas decomposition.

Gas barrier insulators and bushings, including gas-oil and gas-air bushings shall comply with the specified conditions for sealing of enclosures. The Engineer shall be advised of design pressures used and may require test evidence to substantiate performance under extremes of differential pressure and temperature.

SF6 immersed insulation shall otherwise comply with the relevant clauses for insulators and bushings.

3.8.7 Gas Monitors

Gas density monitors complete with alarm and lockout contacts or manometers with pressure switch for alarm and lockout shall be provided. The gas monitor shall be located such that readings can be taken easily standing on the floor. Means shall be provided to enable gas systems to be safely replenished whilst the equipment is in service.

For circuit breaker compartments, a lockout feature shall be provided to prevent operation whenever SF6 gas pressure is less than that permitted by the design for satisfactory operation. Contacts shall be included to initiate alarms to warn of this condition.

Two sets of voltage free electrical changeover contacts shall be provided for every alarm for remote SCADA and repeat alarm facilities in addition to alarm fascias incorporated in the local control panel/marshalling kiosk associated with each primary circuit. Contact multiplying relays may be used.

3.8.8 Position Indicators

Position indicators shall be provided for all circuit-breakers, disconnectors and earthing switches to show whether the main contacts of these switches are in the fully open or closed positions. Position indicator should be directly coupled with shaft drive for all three phases.

Indicators shall be of a reliable mechanical design and be positively driven in both directions by the final drive stage of the contact operating mechanism. Reference marks should be punched or engraved on the main frame for this purpose. Each indicator shall be clearly visible to operating staff at operating control points and access routes provided under this contract.

3.8.9 Temperature Rise

The temperature rise limits shall be in accordance with IEC62271-203. The switchgear shall be capable of carrying the specified rated current at rated frequency continuously in accordance with normal service conditions as defined in IEC 62271-1 as well as site ambient conditions.

The design of sliding type current carrying connectors and joints shall be such that they meet the aforementioned conditions over the full permitted range of movement. Where such joints may be made or adjusted on Site, full details of alignment procedure, together with any necessary alignment tools or gauges shall be described in the maintenance manual and included in the supply of special tools.

3.8.10 Arrangement

The switchgear shall be installed in a building with a cable basement, both being maintained at a slight positive pressure of filtered air such that any SF6 gas released in the building will be discharged externally via pipes from the lowest point.

The Contractor shall supply the necessary permanent type of ladders and galleries for access to all levels of equipment during normal operation or maintenance.

The Contractor shall include in his supply power operated lifting appliances with all accessories as appropriate to the size and weight of component parts of the switchgear which require to be lifted in the course of maintenance or repair. The layout arrangement shall allow for full mobility of the gas handling plant ladders, catway walks etc. along the switchroom.

The offer shall include (a) mobile platform suitable to reach any equipment, (b) Handles of manual operation of D/S, E/S and (c) any special tool required for the operation of the switchgear. 2 nos. of 63 A sockets shall be provided in the GIS room at suitable location for the gas handling plant and HV test set.

3.8.11 Mechanical Construction

Components that may require to be renewed and standard assemblies that may be transferred from one circuit to another shall be interchangeable and where required this shall be demonstrated by the contractor. Flanges shall comply with an appropriate metric standard as regards both dimensions and drilling, where appropriate.

Screwed couplings and fittings shall have pipe threads to ISO Recommendations.

3.8.12 Testing Facilities

Testing flanges/adaptor and associated bushings for 3 phases shall be provided where relevant on each circuit for HV withstand testing of main cables and switchgear. Each testing flange shall be positioned in a separate gas zone compartment which shall be independent of adjacent disconnector and earthing switch gas sections.

3.8.12.1 HV Cable Testing Facility

A set of single and three-phase cable test bushings and the facility for connection to the switchgear shall be provided which will permit the full AC testing of all cable connected circuits. It shall be possible to connect the test bushings without dismantling other equipment and permit testing three single-core cables at the same time or separately by connecting the test bushing to the AC high voltage test kit fitted at a suitably safe place inside the switchgear room. Adequate precautions shall be taken to ensure that any section of busbars insulated by SF6 gas is not subjected to any cable testing voltage unless able to withstand such voltages. Hence the bidder shall indicate if there is any deviation.

3.8.12.2 Removal/Insertion of Links for HV Cable Tests and Primary Injection

The Contractor shall be responsible for the degassing, removal of the cable chamber links at the remote ends, and regassing to facilitate HV Cable Tests and Primary Injection. Once the tests are complete the degassing, insertion of the links and regassing shall be completed thus allowing normal operation of the switchgear. This shall include replacement of gaskets as necessary.

3.8.13 Sealing of Enclosures

To prevent ingress of moisture or leakage of gas during the service life of the equipment, the sealing materials used at all joints and interfaces shall satisfy the following requirements:-

(1) Not affected by SF6 gas

(2) Non-hygroscopic, containing no silicon

(3) Non-aging and non-shrinking

(4) Retain resilience for long periods under stress

(5) Stable under all temperature conditions

Seals including those at compartment partitions shall continue to function correctly throughout the temperature and pressure ranges in service and the pressure differentials, including vacuum and test pressures, during erection, maintenance and subsequent revisions.

Expansion bellows and diaphragms, pressure relief devices and inspection windows shall be designed to be free of leakage under the same conditions as stated for seals.

Where the use of cast aluminium is envisaged the Manufacturer shall submit to PGCB evidence of tests carried out for porosity and extended pressure testing to show the quality of the castings used.

3.8.14 Gas Losses

The Manufacturer should be prepared to guarantee the equipment for a gas loss of not more than 0.5% per annum in any single gas compartment, and not more than 0.5% for the total installation.

3.8.15 Earthing System

All metal parts other than those forming part of any electrical circuit shall be earthed to the earthing system. Any necessary terminals on part of the equipment required for this purpose shall be provided by Contractor. The jointing parts of the earthing conductors/strips are to be properly tinned.

230 kV cable sheath shall be connected to the earthing grid through the link box.

3.8.16 Gas Handling Equipment

Gas handling plant shall be provided at each installation to permit emergency topping up of gas in the switchgear in the event of leakage and for use during any maintenance works.

The mobile gas handling unit, the size of which shall allow full mobility within the switchroom, shall be included for the complete sampling, testing, filtering, drying, extraction and refilling of SF6 gas. This unit shall be self-contained and comprise of a wheeled trolley housing all necessary compressors, vacuum pumps, filter, etc. gauges, piping and controls etc., together with a gas storage tank with usable capacity. The unit shall be capable of evacuating air from the switchgear compartments and replenishing them with gas at the end of a maintenance period. Facilities shall also allow for circulation of the gas from a compartment through filters in order to extract moisture pressure.

Additional mobile or static storage (at least one full cylinder of SF6 gas together with one empty cylinder) shall be provided for use in combination with the gas trolley and to extend storage facilities.

All necessary pipe work, flexible hoses, couplings, valves, pressure and vacuum gauges shall be included to enable interconnection between the switchgear compartments, gas trolley and storage tanks and the cylinders provided by major producers of SF6 gas.

To enable safe maintenance to be carried out on any portion of the switchgear when all electrical supplies to the local control unit are switched off two portable gas alarm units shall be provided. The alarm units shall be self-contained and capable of giving clear audible warning should the gas pressure in any adjoining gas-filled chamber become unsafe. The cost of these equipment shall be included in the GIS price.

Technical Data:

Vacuum Pump		
Nominal suction capacity	:	l0m3/h
Achievable final vacuum	:	< 1 mbar
Compressor		
Theor. intake volume	:	5, 7 m3/h
Suction pressure	:	p = 0,8 to 3 bar (for a short time up to 0, 5 bar)
Max. counter-pressure	:	p = 50 bar
Storage performance	:	90 kg SF6
Filling performance	:	140 kb SF6/h.

An approved portable SF6 gas leakage detector, oxygen analyzer, moisture meter and manual operating handles/tools (for circuit breakers, disconnectors, earth switches) shall be provided for each substation.

3.9. APPARATUS

3.9.1 Circuit Breakers

3.9.1.1 Operating Duty and Performance

3.9.1.1.1 General

The requirements of IEC 62271-100 in respect of type tests, routine tests, service, operation and the making and breaking of fault currents shall apply to the specified circuit breakers.

Circuit breakers shall be complete with spring or hydraulic operated mechanisms. Where circuit breakers require other services these shall be included in the supply and erection of the common services installation at each substation, and shall include alternative back up facilities.

Offers of circuit breakers shall include proof that a satisfactory period of commercial service experience of not less than three years in climatic conditions similar to Dhaka has been obtained with the type and rating put forward; failure to provide this proof may result in rejection of the tender.

3.9.1.1.2 Rate of Rise of Restriking voltage

Attention is drawn to the transient recovery voltage (TRV) requirements of the IEC Standards. where not specifically stated in the test certificates submitted with the Tender, the Tenderer shall certify that the TRV to which the circuit breaker was subjected during the short circuit tests was the most severe condition that could be imposed by the available test plant for a first phase-to-clear factor of 1.3

Any device incorporated in a circuit breaker to limit or control the rate-of-rise of restriking voltage across the circuit breaker contacts shall likewise be to PGCB's approval and full descriptions of any such device shall be given.

Evidence shall be submitted with the tender to verify that all circuit breakers when interrupting faults on the secondary side of a transformer the transient recovery voltage conditions, that could arise will not exceed the tested interrupting capabilities of the circuit breaker proposed.

3.9.1.1.3 Interrupting Duty

In addition to the requirements of IEC 62271-100 for interrupting terminal faults all circuit breakers shall be capable of coping with the interrupting duties produced by the switching of low inductive currents associated with reactors and transformer magnetizing currents and by the switching of capacitive currents associated with overhead lines, cables and capacitors banks as may be applicable. Circuit breakers for these duties shall be of the restrike-free type only.

All circuit breakers shall also be cable of interrupting currents associated with short-line faults and the out-of-phase switching conditions that may occur in service.

3.9.1.1.4 Fault Clearance Time

The overall fault clearance time including relay operating time shall be in accordance with the requirements specified.

3.9.1.2 General Arrangement

Facilities for measurement of circuit breaker contact resistance and timing tests without removal of covers or SF6 gas filling shall be provide. Full details of the testing procedures shall be submitted with the Bid.

Means shall be provided to allow access for the inspection and maintenance of fixed and moving contacts and other enclosed components.

Circuit breakers use the SF6 gas conforming to IEC or other approved standard as the insulating medium as well as for arc quenching.

Circuit breakers shall operate on the principle of self generating gas pressure within the interrupter for arc extinction. e.q puffer type. A lockout feature shall be incorporated to prevent operation of the circuit breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with rated duty. A pressure switch (temperature compensator type) operated SF6 low in CB alarm shall be incorporated at LCC, Remote Control centre as urgent feeder alarm at SCC to give indication of falling gas pressure prior to lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by integral filters.

Sufficient nos. of N/O and N/C auxiliary electrical contacts shall be provided for using interlocking circuits and for states indication at the remote and supervisory control centres and any other requirement. At least 10% spare N/O and N/C contacts shall be wired up to LCC for future use by PGCB.

3.9.1.3 Operating Mechanisms

The circuit breaker operating mechanism shall be power operated and of the type specified. Operation will normally be from a remote or supervisory position but facilities shall be provided for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters shall be fitted to all circuit breaker mechanisms.

The mechanism and its control scheme shall be such that, in the event of an electrical tripping pulse being applied to the circuit breaker during the closing stroke, or of the mechanism falling to latch in the closed position, the circuit breaker shall open fully and in such a manner as to be capable of interrupting its rated breaking current.

The mechanism and its control scheme shall be such that the mechanism shall not make repeated attempts to close the circuit breaker when the control switch is held in the CLOSE position in the event of failure to latch on the first closing attempt or in the event of a trip signal being given to the circuit breaker i.e. anti pumping facility to be provided.

The electrical closing and tripping devices, including direct acting solenoid coils and solenoid operated valves, shall be capable of operation over the ambient temperature range when the voltage at their terminals is any value within the voltage range stipulated in IEC 62271-100 and in addition over the range of all operating conditions of the batteries and chargers supplied under this Contract.

The circuit breaker shall preferably be driven by a single mechanism coupled to the three phases.

The circuit breakers shall be provided with the facility for measuring the electrical timing of the contacts.

All circuit breaker operating mechanisms shall be fitted with independent duplicate shunt trip coils suitable for either independent or simultaneous operation.

On feeder circuits Trip Coil 1 (TC1) shall be operated by all circuit protection and intertrips except Main 2 protection. Trip Coil 2 (TC2) shall be operated by Main 2 protection and the local, remote and supervisory control switches.

On Bus Coupler and -Bus Section-circuits TC1 shall -be -operative- by bus zone protection and TC2 by overcurrent protection and controls.

On Transformer and Generator circuits TC1 shall be operated by all protection and intertrips except REF and TC2 by REF and controls.

Power closing mechanisms shall be recharged automatically for further operations as soon as the circuit breaker has completed the closing operation and the design of the closing mechanisms shall be such that the circuit breaker cannot be operated inadvertently due to external shock forces resulting from short-circuits, circuit breaker operation, or any other cause.

Operating mechanisms shall be capable of storing energy for at least two complete closing and tripping operations or one O-C-0 operation, local to the equipment and without recharging. Mechanisms shall preferably utilize dc supplies for recharging duties.

Means shall be provided for the CB manual (non-electrical) tripping of the circuit breaker, preferably by a shrouded push button and facilities shall be provided for locking off this means of tripping. It shall not be possible to lock mechanically the trip mechanism so as to render the electrical tripping inoperative.

Facilities shall be provided to permit manual slow closing and slow opening of the circuit breaker for maintenance purposes. It shall not be possible to “slow close" or "slow open" a circuit breaker when connected in the normal service condition.

3.9.1.3.1 Hydraulic Operating Mechanisms (Not Applicable)

3.9.1.3.2 Spring Charged Mechanisms

Circuit-breakers fitted with power charged spring operated closing mechanism shall also meet the following requirements.

When fully charged the spring mechanism shall have sufficient stored energy to permit the operating sequence O-C-0/2 C-0 to be performed following the loss of supply to the charging motor.

The mechanism shall be charged automatically, for further operations, as soon as the circuit breaker has completed a closing operation. The time required to power charge the spring shall not exceed 30 (as per IEC Standard) seconds.

The spring shall be fully charged before it can be released to close the circuit breaker. It shall not be possible for the breaker to close whilst the spring is being charged.

Manual Spring charging facility shall be provided.

A mechanical indicating device shall be provided to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of “spring discharged".

An indicating device shall be provided at the local control panel and the main control room and also over the supervisory system to indicate a spring failing to be charged by a pre-set time after circuit breaker closing.

3.9.2 Circuit Disconnectors and Earthing Switches

3.9.2.1 General

Circuit Disconnectors and Earthing Switches shall be supplied as shown on the contract drawings and as indicated in the Schedules. Each diconnector and E/S shall be labeled with SCADA numbers as per SLD by providing permanent engraved stickers.

Transformer circuit modules shall be equipped with not less than two maintenance earthing switches, one on either side of the transformer circuit breaker.

Each busbar shall also contain high speed make-proof earthing switch as per the single line diagram.

In case of designs incorporating double isolation and interposing earthed metallic screen shall provide similar facilities which enable safe access for testing, inspection, maintenance and extension whilst other parts are in service.

Isolating and earthing switches shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive. Isolating switches shall be arranged for operation while the equipment is alive, but will not be required to break current other than the charging currents of open busbars and connections (including circuit-breaker bushings) or load currents shared by parallel circuits under the conditions of this Specification.

Isolators shall be housed in compartments partitioned from the circuit breakers and the busbars or feeders with which they are associated.

Isolators with double isolations, may be housed into two adjacent compartments. It shall be possible with such partitioning and with the isolator compartments maintained at full gas pressure, to carry out high voltage insulation withstand tests on outgoing circuit cabling or on sections of busbar, without taking adjacent equipment or sections of busbar out of service.

Load making and breaking switches with fault making capability shall be provided which shall be suitable for switching on load without detriment to the equipment and under normal duties up to the circuit rating specified.

Switch mechanisms shall be so designed that the isolator cannot be opened by forces due to currents passing through it and shall be self-locking in both the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Power operated drives shall be provided which shall be suitable for local, remote and supervisory control (supervisory control of earth switches is not required) and should be fitted with a removable emergency manual operation facility. It should be possible to lock-off the manual and local facility and padlock the mechanism in the open and closed positions with the motor automatically disengaged (isolator and earth switch).

Local mechanical position indicators shall be provided on all switches and shall be visible from ground level. Transparent window shall have to be provided as required to see the Disconnector and Earth switch contact status(Close or Open).

For safe earthing of the busbars and feeders, high speed fault making spring driven earth switches shall be provided. The mechanisms shall be electrically operated with provision for local manual operation. The contacts of these earth switches shall have the same fault making capability as that of the circuit-breaker.

Each section of busbar which can be electrically isolated from other sections of busbar by means of isolators or circuit-breakers shall incorporate high speed earthing switches as specified above.

Slow speed maintenance earthing switches shall be manually and electrically operated from the local position only. Positive mechanical and electrical interlocks shall be provided to prevent unintentional use of this earthing equipment.

Selected earthing switches shall be arranged such that, with a minimum use of tools and special fittings, they may be used to facilitate such tests as CT primary injection, contact timing and voltage drop measurement without the necessity to open gas-filled compartments. Detailed means of performing these tests, shall be provided.

Each Isolator/Earth Switch shall have its own separate power and control supply and supplied from the station battery.

Sufficient nos. of N/O and N/C auxiliary electrical contacts shall be provided for using in interlocking circuits and for status indications at the remote and supervisory control centres and any other requirement. At least 10% spare N/O and N/C contacts shall be wired upto LCC for future use by PGCB.

3.9.2.2 Disconnectors

Disconnectors shall be of the metal enclosed design and shall generally comply with the requirements of IEC 62271-102, 62271-104 and 62271-203.

Disconnectors shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive.

Disconnectors shall be provided with motor driven mechanisms and shall open and close all three phases simultaneously. It shall not be possible for the disconnectors to open or close inadvertently due to forces which may occur in service or under short-circuits.

The mechanisms shall be capable of being locked and secured by padlock in the open or closed position.

In the event of driving motor failure, means for hand operation shall be provided which are operable from ground level or walkways provided.

While doing a hand operation of disconnector, driving motor supply shall be cut off by appropriate means.

All disconnectors shall be fully interlocked with associated circuit breakers, disconnectors and earthing switches to ensure safe operation of the equipment under all service conditions.

The disconnector shall be interlocked with CB is arranged in such a way that CB shall not be allowed to close unless the concerned disconnector is fully closed, ie. Late make type auxiliary contact shall be used for this purpose.

Electrical interlocking is required for maintenance and operation.

The insulation level for the isolating distance between disconnector contacts shall be at least 15% higher than that for the remainder of the equipment.

Disconnectors shall be capable of switching load currents when shunted by a parallel path (on-load bus transfer) and capacitance charging currents associated with open busbar, bushings and capacitor voltage transformers. Test certificates on the capabilities of on load bus transfer of disconnectors are to be provided.

If the diconnectors are expected to generate fast rising transients during interruption of capacitive currents, adequate protection shall be provided for transient voltage control.

3.9.2.3 Maintenance Earthing Switches

Earthing switches shall generally comply with the requirements of IEC 62271-100 and 62271-203.

Earthing switches integrally mounted with disconnectors or separately mounted shall be provided for earthing already isolated sections of gas insulated switchgear in order to provide safety maintenance. Motor operated mechanisms shall be provided but it shall be possible to operate the switch manually in emergency conditions.

The earthing switch, when in the closed position shall have a short-time current withstand as specified for the feeder. No burning or welding of contacts shall occur.

Provisions for testing purposes shall be incorporated in the design of earthing switch to facilitate primary current injection tests and other low voltage checks. Fully insulated designs of earthing shall incorporate removable earth links suitable for the short-time current rating specified. It shall be possible to apply maintenance earths on either side of the test zone for safety reasons.

All earthing switches shall be mechanically interlocked with associated circuit breakers and disconnectors so that it shall not be possible to close an earthing switch onto a live circuit or to make the circuit alive when the earthing switch is closed.

Direct visual indication of the earthing switch position should be provided, with clear markings to show that the device is fully open or closed.

3.9.2.4 High Speed Earthing Switches

These earthing switches shall be capable of making onto a live circuit and suitable for high speed power operation. It shall be impossible to slow close these earthing switches.

They shall be located at all feeder terminal points and busbars or other location where there is no certainty that the point to be earthed is not energised.

High speed earthing switches shall be capable of interrupting induced currents as may be necessary when opening the earthing switches used for grounding one out of two or more long parallel circuits.

The operating mechanism of High Speed Earthing Switches shall be motor wound spring operated type with one of the following features :-

a) The closing spring shall remain in discharged position when the switch contacts are in open position. The closing spring shall be charged only when the closing command is given either electrically or manually and the contacts shall close automatically after the spring is fully charged.

b) If earthing switch is provided with the design in which closing spring is charged and latched in the open & close position of the switch, then mechanical locking arrangement shall be provided to avoid un-intentional closing of the switch either electrically or manually.

In both the designs, facility for padlocking the mechanism in the open position of the switch shall be provided.

The design of the Earthing Switch shall be approved by PGCB.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and incorporate a disconnectable earth strap.

These earthing switches shall otherwise be in accordance with the requirements for maintenance earthing switches.

3.9.3 Current Transformers

Current transformers shall be supplied suitable for the duty specified and comply with the requirements of IEC 60044-1 and BS 3938 as appropriate.

Current transformers, where specified, shall be SF6 gas insulated, shall be compatible with the switchgear and shall preferably not contain any hygroscopic insulating material which could affect the SF6 gas in either the current transformer or in the associated switchgear chamber.

Current transformers shall comply with the requirements of the common sections of this Specification. Where separate terminal boxes are used for current transformer secondary wiring, the identifying labels shall be fitted to the terminal boxes in a conspicuous position but not on removable covers.

Current transformers including primary conductors shall have a short time current rating and duration not less than that of the associated switchgear. All current transformers shall have sufficient overload capacity to permit continuous operation with currents up to 150% of the rated current of the associated equipment.

Secondary windings of each current transformer shall be earthed through a withdrawable link at one point only; in the relay panel for protection circuits and in the control panel for instrumentation.

Current transformers for tariff metering shall not be used for any other purpose. Current transformers for statistical metering may also be used for other instruments and protection.

Where double ratio secondary windings are specified a label shall be provided at the secondary terminals-of the current transformer indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams.

CT sizing calculations shall be submitted to the PGCB for approval.

Where double ratios are specified and current transformers with multiple windings are tendered, it-shall be possible to select either ratio for each winding without alteration to the number of primary turns.

The characteristics of current transformers used for protection circuits shall include the following requirements.

(a) For overcurrent protection, they shall not saturate, change ratio or produce harmonic voltages in the secondary winding which will affect the accuracy of the relay with primary currents up to 20 times rates full load current.

(b) For earth fault protection and balanced forms of protection, when connected as in-service, they shall not produce spill currents in excess of half the minimum operating current of the relay but provide stable equipment with primary currents up to 20 times rated full load.

(C) Each protection scheme shall be provided with appropriate current transformers for optimum operation of the scheme. Provision should be made to carry primary injection test of bushing CTs for 100% rating.

Terminal boards shall have shorting/disconnecting links to allow testing with the circuit in service and on load. It shall be possible to carry out primary injection testing of the CTs with 100% rating when the switchgear is fully assembled, or retesting of the CTs during the service life of the switchgear without interruption of supply to adjacent circuits or any part of busbar. The testing facilities provide in the design for site testing shall be stated by the Tenderer.

The contractor should clearly mention the continuous rating of earth switches and their associated cables for the purpose of primary injection tests. The secondary windings of each set of current transformers shall be capable of being open circuited for one minute with the primary winding carrying the rated current. The secondary wiring of all CT's shall be brought to a common terminal block located within the local control cubicle.

The polarity of the primary and secondary windings of each transformer shall be clearly indicated at the respective terminals and in addition labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer winding.

Neutral CT for REF protection and any other CTs which require to be matched with switchgear CTs will be manufactured by switchgear manufacturers and hand over to transformer manufacturer for installation. Suitable mounting arrangement is to be made by the transformer manufacturer.

3.9.4 Voltage Transformers

Indoor voltage transformers, where specified, shall be SF6 gas insulated, shall be compatible with the switchgear and shall preferably not contain any hygroscopic insulating material which could affect the SF6 gas in either the voltage transformer or in the associated switchgear chamber.

Voltage transformers shall comply with the common sections of this Specification, comply with the requirements of IEC 60044-2 and shall be provided with requirment mentioned in schedule- A of Volume 3 of 3.

The rated secondary voltage per phase shall be 110/√3volts in the case of star connected windings and the rated voltage factor shall be 1.2 continuous; 1.5 for 30 seconds.

Facilities for isolating the primary connections without having to lift the VT from the switchgear shall be provided. This primary isolation shall be without degassing.

It shall not be possible for voltage transformer secondary windings to be connected directly in parallel, except through interposing voltage transformers associated with a synchronising scheme. To prevent any possibility of back energizing a VT secondary winding via synchrorilsing circuits, circuit breaker auxiliary contacts which are of the late make-early break type shall be employed.

Voltage transformers shall be capable of carrying continuously, without thermal damage 150% of their rated output.

Voltage transformers on feeder circuits shall be located on the feeder side of the circuit breaker outside the protected zone covered by the busbar protection. They shall however be included in the protected zone afforded by the feeder protection.

Primary connections shall have the same short time current rating as the associated switchgear.

Each secondary winding of the voltage transformers shall be protected by suitable approved fuses and links which shall be located as close as possible to the voltage transformer, preferably within the terminal box. All secondary winding connections, including both ends of the secondary winding shall be brought out to the fuses and links.. The fuses and links shall be connected to approved terminal blocks for termination of multicore cables. A metallic label shall be provided and fixed at the voltage transformer clearly indicating the connections required for each winding.

Separate sets of MCBs shall be provided at the VT for:-

(a) Each protection scheme
(b) Instruments, disturbance recorder, fault locator etc.
(c) Synchronising

The circuits for each main protection scheme shall be segregated in separate multi-core cables from the VT to the protection panels. An alarm (VT. failure) shall be provided for each set of MCBs.

The neutral point of each voltage transformer secondary circuit shall be earthed at one point only via a separate removable link of approved design. The earth link shall be situated in an accessible position and suitably labeled.

A magnetization curve shall be provided for each voltage transformer for approval by PGCB.

The location of the voltage transformers to be installed on the primary switchgear shall be approved by PGCB.

Fixed ladders and/or cat walk structures with handrails are to be provided for the VTs for inspection/testing/replacement of fuse, etc.

Mechanical shock indicators shall be fitted to VTs prior to dispatch from the factory, to indicate how the VT was handled during transit and to determine if detailed inspection is required at Site.

Electromagnetic voltage transformers shall be capable of discharging the capacitance of line, cables and switchgear which may remain connected to them during switching operations. The Tenderer shall declare any limitations of the equipment for this duty.

The contractor shall ensure that no disruptive over voltages will be generated due to ferro-resonance phenomena and if necessary by suitably connecting resistors across the secondary of VT after approval of PGCB. All necessary site tests are to be performed on VTs before commissioning. Details of the test procedures and test formats are to be provided.

3.9.5 Feeder and Transformer Connections

3.9.5.1 General

SF6 immersed cable sealing end chambers or SF6 gas insulated bus ducts shall be provided as specified for outgoing circuits.

For connection to the transformer using SF6 gas insulated bus ducts and air insulated bushing. The supply and installation of such gas insulated bus ducts and Air Insulated Bushing shall be included under this contract.

When the circuits are connected via cables directly to the SF6 switchgear terminals the cable and sealing ends shall be to the specification given in below in Clause 3.9.5.2, 3.9.5.3 and 3.9.5.4.

Connections shall be suitable for the specified continuous and short circuit current ratings. Where necessary, expansion joints shall be provided to accommodate differential movements between the switchgear phase terminals and conductors.

The manufacturer of the switchgear is required to coordinate design of SF6 filled enclosures with that of cable sealing ends and transformers supplied by other manufacturers such that the integrity of gas and/or oil pressure compartments is maintained.

Facilities shall be provided for high voltage a.c. testing and conducting cable fault location measurements of cabled circuits.

To reduce the effect of solar gain all SF6 or other types of insulated bus ducts exposed to direct sunlight shall be covered with metallic sun shielding (If the installation is outdoor partly).

3.9.5.2 Cable Sealing Ends

Cable sealing ends shall be suitable for terminating the cables specified directly into the GIS switchgear. The dimensions and terminal arrangements, together with details of filling medium of the sealing end shall be submitted for approval by PGCB before manufacture is commenced.

All sealing ends shall be suitable for filling and shall be designed with joint faces which will ensure leak-free operation and exclude the entry of oil or gas.

Where required to reduce local heating when single-core cables are adopted, non-magnetic gland plates shall be provided or alternatively, non-magnetic inserts.

Design of cable termination equipment must ensure that the following conditions are maintained throughout the life of the equipment.

(a) The insulating material, either gas or oil, from inside the cable does not escape and penetrate the switchgear enclosure.
(b) The SF6 gas does not enter the cable from the enclosure.
(c) The cable sealing end does not introduce moisture into the gas in the sealing end enclosure.
(d) The sealing end is capable of withstanding the cable test voltages and differential pressures without damage including overpressure of +30% of normal operating pressure.

3.9.5.3 Insulating and Earthing

Sealing ends shall be provided with all fittings including flexible connections where necessary. Stress cones or other approved means for grading the voltage stress shall be provided for insulating the cable within the sealing end. (The insulated flange and external casing shall be provided by the cable manufacturer). Glands shall be insulated from the chamber.

The insulation between cable and chamber shall be capable of withstanding a dry high voltage test of 3kV a.c. for one minute.

Removable links shall be provided close to the GIS to enable sheath tests to be carried out and to prevent arcing to adjacent metal framework during isolator operation.

3.9.5.4 Material

Porcelain or molded insulators used in the manufacture of cable sealing ends shall be sound, free from defects and thoroughly vitrified so that the glaze or surface treatment is not depended upon for insulation.

The insulators and fittings shall be unaffected by the filling media or rapid temperature changes likely to arise when operating in the Site conditions and shall be designed so as to facilitate cleaning.

Porcelain shall not engage directly with hard metal and, where necessary, an approved resilient material shall be interposed between the porcelain and the end fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

All fixing material used shall not enter into chemical action with the metal parts or cause fracture by expansion during service. Where cement is used as a fixing medium, the thickness of cement shall be as small and even as possible and proper care shall be taken to centre and locate the individual parts correctly during cementing.

Each porcelain or molded insulator shall have marked upon it the manufacturer's identification mark and such other mark' as may be approved to assist in the representative selection of insulators for the type tests. The mark shall be clearly legible and also visible after assembly of end fittings and shall be imprinted before firing.

When an insulator bearing a certain identification mark has been rejected, no further insulators bearing this mark shall be submitted and the Contractor shall satisfy PGCB that adequate steps will be taken to mark or segregate the insulators which have been rejected in such a way that there shall be no possibility of such insulators being re-submitted subsequently for test or being supplied.

3.9.5.5 Transformer/Cable Sealing End Enclosures (Not Applicable)

3.9.6 Surge Arresters (Metal Oxide without gaps for A.C. systems)

Indoor GIS surge arresters and outdoor GIS surge arresters shall be of the type metal oxide arresters without gaps complete with surge counters and shall fulfill requirements as per IEC 60099-4, IEC 60099-5 and PGCB specification. The Contractor shall demonstrate by calculations that the surge arresters will adequately protect the switchgear arrangement proposed.

SF6 gas pressure monitors for the surge arresters shall comply with clause 3.8.7 above.

3.9.7 Control Equipment

3.9.7.1 Local Control Cubicle

3.9.7.1.1 Functions

Each circuit breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously.

Closing of the circuit breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Local control cubicle shall be suitable for installation in a separate place or mounted with the GIS bay. Status indications in the LCC shall be semaphore type or LED type.

Circuit breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

If a disconnector or earth switch is not the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

Local manual release facilities shall be provided for closing and tripping the circuit breaker. The operation of both releases shall be subject to lockout if insufficient stored energy is available. Local manual releases shall be provided with locking off facilities.

Sufficient electrical terminals shall be provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and local ring main supplies.

Where control cabling between the local control cubicle and the switchgear are connected by plug and socket boxes, the plugs and sockets shall not be inter-changeable.

Hydraulic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breakers, disconnectors and earth switches shall be located in a separate cubicle compartment.

3.9.7.1.2 Design

Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles. Local control cubicles shall be provided to be free standing or mounted on the GIS with front access, and shall be equipped with anti condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation.

Cubicles shall be of rigid construction, preferably folded but alternatively formed on a framework of standard rolled steel sections and shall include any supporting steelwork necessary for mounting on the circuit breaker or on concrete foundations. Access to all compartments shall be provided by either removable panels or doors. All fastenings shall be integral with the panel or door and provision made for locking. Doors and panels shall be fitted with weatherproof sealing material suitable for the climatic conditions specified. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen.

The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door operating switch, shall be fitted at the top of each section.

The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus.

All the control switches shall be internal i.e. installed behind a lockable glass door.

3.9.7.1.3 Anti -condensation Heaters

Anti-condensation heaters of an approved type shall be provided inside each cubicle. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The heaters shall have individual humidity stat and thermostatic control and shall be arranged to cut off when the cubicle internal temperature exceeds between 30-35°C and humidity less than 30%. A master heater circuit switch shall be provided on the switchboard or panel with an indicating lamp to show whether the supply is on or off. The location of the heater circuit switch and indicating lamp shall be either on a common panel or in such a location that it does not require moving when extensions are provided. The heaters shall operate from the specified single phase a.c. supply. Isolation facilities for a.c. supply shall be provided in each panel.

3.9.7.2 Auxiliary Switches and Contactors

Auxiliary switches positively driven in both directions shall be provided on all circuit breakers and isolators for local and remote indication, control and interlocking and repeat relays where necessary. Busbar protection has direct driven auxiliary contacts for CT circuits. With each circuit breaker, isolating device, and earthing device, there shall be supplied all necessary auxiliary switches, contactors and mechanisms for indication, protection, metering, control, interlocking, supervisory and other services. All such auxiliary switches shall be enclosed in dust free housing. Not less than eight (4 NO + 4 NC) spare auxiliary switch ways shall be provided with each circuit breaker and not less than six (3

NO + 3 NC) on all other devices. All auxiliary switches shall be wired up to a terminal board in the local control cubicle of the switchgear whether they are in use or not in the first instance and shall be arranged in the same sequence on appropriate busbar coupling and sectioning equipment that sections or sets of busbars cannot be paralleled by means of the busbar isolating devices unless a parallel circuit is already closed through the circuit breakers of the all equipment.

Switches shall be provided to interrupt the supply of current to the tripping mechanisms of the circuit-breakers directly the operation of the latter has been completed. All such switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism and shall be adequately protected. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Direct acting auxiliary switch make before break contacts shall be used in conjunction with busbar protection schemes.

Auxiliary contactors shall be provided only where the circuit requirement cannot be met by the auxiliary switch arrangements and multiple contactors and relays will not be accepted in lieu of auxiliary switches except as specifically approved by PGCB.

3.9.7.3 Interlocking

An interlocking scheme shall be provided which takes into account the following basic requirements.

(a) To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.

(b) To prevent incorrect switching sequences which could lead to a hazardous situation to plant, equipment and personnel.

The interlocking scheme shall be electrical for all operational interlocks but shall be effective when the equipment is being controlled locally, under emergency hand or from a supervisory position.

All electrical interlocks shall so function as to interruption the operating supply and a system of interlocks shall be provided which cover the emergency hand operation of apparatus which is normally power operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

Where key interlocking is employed, tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency tripping device shall be kept separate and distinct from the key interlocking.

Circuit breakers closing shall be possible irrespective of the busbar and circuit isolator position.

Disconnecting switches shall be so interlocked that they cannot be operated unless the associated circuit breaker is open except that where double busbar arrangements are specified, on-load transfer of feeder circuits from one busbar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

Earthing switches shall be interlocked such that they cannot be operated unless the associated isolator is open.

All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

In double busbar stations where provision for on-load changeover of busbars is specified, the busbar isolating devices shall be so interlocked with the appropriate busbar coupling and sectioning equipment. In all other circumstances, the busbar isolating devices of equipment other than busbar sectioning and coupling equipment shall be so interlocked that their respective circuit breakers can only be coupled to one set of busbars at a time. It shall not be possible to parallel sections of busbars except through the circuit breakers of the busbar coupling and sectioning equipment.

For each primary circuit, an interlock bypass switch shall be provided, mounted on the local control cubicle, for use during commissioning of the Switchgear. The switch shall be key operated (common key for each circuit) spring return to normal and provided with sufficient direct drive contacts to enable operation' of the- circuit breaker, isolators and earth switches independent of the electrical interlocking circuitry. By-passing of interlocks shall only lye possible in the local (Maintenance) position.

Interlocking philosophy shall be provided by the switchgear manufacturer and shall be submitted for PGCB's approval.

3.9.7.4 Locking Facilities

Locks and locking facilities shall be provided on each item of substation equipment as detailed below and shall be additional to the mechanical interlocking devices specified in the above clause.

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.

The following locking facilities shall be provided with common key operated locks.

(a) Circuit breaker mechanisms in the open position and any associated manual operating device in the neutral position.

(b) Isolating switches in both open and closed positions.

(c) Operating cubicle access doors.

3.10 TESTS

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

SECTION 3B

HV AIR INSULATED SWITCHGEAR EQUIPMENT

TABLE OF CLAUSES

SECTION 3

HV AIR INSULATED SWITCHGEAR EQUIPMENT

3.1 SCOPE

These clauses describe the General Technical Requirements for the new, 230 kV ,132kV a nd 33kV outdoor, open terminal circuit breakers & general switchyard equipment, and shall be read in conjunction with the Project Requirements, Schedules and Drawings in the specif ication.

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

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

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

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

3.2 REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

3.2.1 IEC Standards

IEC 60060 High Voltage test techniques

IEC 60071 Insulation Co-ordination

IEC 60099 Surge arresters

IEC 60044-1 Instrument Transformer-Part 1: Current transformers

IEC 60044-2, Instrument Transformer-Part 2: Voltage transformers

IEC 60044-5 Instrument Transformer-Part 5: Capacitive Voltage transformers

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

IEC 60305 Insulators for overhead lines with a nominal voltage above 1000V - Ceramic or glass insulator units for ac systems - Characteristics of insulator units of the cap and pin type.

IEC 60376 Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment

IEC 60383 Insulators for overhead lines with a nominal voltage above 1000V

IEC 62155 Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V

IEC 62271-1 HV switchgear and controlgear-part1: common specifications

IEC 62271-100 HV switchgear and controlgear –part100: AC circuit breakers

IEC 62271-102 HV switchgear and controlgear-part102: AC disconnectors and earthing switches

IEC 62271-200 A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

3.2.2 British Standards

BS 7884 Specifications for hard-drawn copper and copper cadmium conductors for overhead power transmission purposes

BS EN 60383-2 Insulators for overhead lines with voltage greater than 1000V.

BS 159 Specifications for HV busbars and busbar connections

BS 215S Specifications for aluminium conductors for overhead transmission

BS EN 13600 Specifications for high conductivity copper tubes for electrical purposes

BS 2898 Specifications for wrought aluminium for electrical purposes. Strip with drawn or rolled edges.

BS 3288 Insulator and conductor fittings for overhead power lines.

BS 3938 Current Transformers

BS 6651 Lightning Protection

BS 7354 Code of practice for design of HV open terminal stations.

3.3 DESIGN PRINCIPLES

3.3.1 General Requirement

The normal operations will be effected from the Naional Load Dispatching Centre (NLDC) at Aftabnagar. The bidder shall take into consideration the unmanned operation of the substati on in his design (No operators are necessary in the new substation control rooms where Su bstation Automation System considered).

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

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

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

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

Supervisory control from NLDC-provision of control of circuit breakers and disconnectors sw itches 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 assembl y and on the local control cubicle. In case of labels not visible when standing on the floor, ad ditional 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 sw itchgear.

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

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

3.3.2 Availability for Maintenance, Repair, Extensions, Testing

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

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

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

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

3.4 OUTDOOR HV SWITCHGEAR

3.4.1 Switchgear - Design and Performance

The switchgear shall be suitable for outdoor location and capable of continuous operation u nder the climatic conditions existing on site. It shall be designed to comply with this Specific ation and relevant IEC and British Standards where applicable.
In all cases the ancillary plant necessary to complete installation of the equipment shall be i ncluded in the Contract. The disposition of plant in any substation is to be such that the oper ation of any item of plant under the specified service conditions, shall in no way create a con dition that could adversely affect the performance of adjacent circuit breakers or any associa ted 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, maintenance and extension whilst the remaining sections of equipment are alive. Electrical clearances provided between isolated equipment and nearest live metal work shall not be less than the distance data as mentioned in sub-clause 1.2.3 of Section - 1 of this specification (vol 2 of 3). Insulation creepage distances shall not be less than 25mm per kV rated voltage between phases.

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

3.4.2 Current Ratings

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

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

3.4.3 Corona

Equipment shall be designed so as to minimise corona or other electrical discharge and radio interference. The Contractor is to confirm and ensure adequacy of design in terms of corona performance. Ion current density shall be less than 20 na/sqm at ground level. Tests for corona and radio interference shall be carried out by the Contractor as per relevant IEC standard. The requirements regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. In case the connector is not available then equivalent connector may be used. If corona rings are required to

meet these requirements they shall be considered as part of that equipment and included in the scope of Work.

3.4.4 Local, Remote and Supervisory Control

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

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

3.4.5 HVAC Circuit-Breakers

3.4.5.1 General

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

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

The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure for CB and control cabinets, their foundation bolts and all other circuit breakers accessories required for carrying out all the functions the CB is required to perform. All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided. The support structure of circuit breaker as well as that of control cabinet shall be hot dip galvanised. All other parts shall be painted as per approved shade.

3.4.5.2 Operating Duty and Performance

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

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

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

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

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

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

ii) Interrupting line charging current as per IEC.

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

iv) Clearing bus faults on 132kV AC switchyard.

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

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

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

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

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

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

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

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

3.4.5.3 Constructional Features

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

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

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

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

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

ii) All gasket surfaces shall be smooth, straight and reinforced, if necessary, to minimize distortion and to make a tight seal. The operation rod connecting the operating mechanism to the arc chamber shall have adequate seals. The SF6 gas leakage should not exceed 1% per year. In case the leakage under specified conditions is more than 1% after one year of commissioning of the circuit breaker, the manufacturer shall have to supply free of cost, the total make up gas requirement for subsequent ten(10) years based on actual leakage observed during first year of operation after commissioning. In the interrupter assembly there shall be an absorbing product box to minimize the effects of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas as well as its decomposition products.

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

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

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

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

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

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

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

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

d) Provision shall be made for attaching an operational analyser after installation at site to record contact travel, and making measurement of operating timing, synchronization of contacts in one pole and dynamic contact resistance measurement.

3.4.5.4 Sulphur Hexafluoride Gas (SF6 Gas)

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

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

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

3.4.5.5 Insulators

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

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

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

i) Pressure test as a routine test

ii) Bending load test as a routine test

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

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

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

d) Jointed porcelain shall not be accepted.

3.4.5.6 Mandatory Maintenance Equipment: deleted

3.4.5.7 Operating Mechanism and Control

General Requirements

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

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

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

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

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

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

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

Control

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

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

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

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

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

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

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

Spring Operated Mechanism

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

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

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

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

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

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

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

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

3.4.5.8 Support Structures

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

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

3.4.5.9 Terminal Pads

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

3.4.5.10 Fittings and Accessories

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

a) Cable glands, lugs, ferrules, etc.

b) Local/Remote changeover Switch

c) Open/Close buttons and Operation counter

d) Pressure gauges

e) Control switches to cut off control power supply

f) MCBs/MCCBs as required

g) Anti-pumping relay

h) DC auxiliary power supervision relay.

i) Pole discrepancy relay

j) Rating and diagram plate in accordance with IEC

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

3.4.5.11 Tests

<u>Type Tests</u>

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

<u>Routine Tests</u>

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

<u>Site Tests</u>

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

3.4.5.12 Technical Parameters

The Contractor shall determine the technical parameters of breakers to be provided. Refer to Appendix-A3 of Schedule-A of volume 3 of 3 (Schedule of Requirements) for the technical parameters of the circuit breakers generally used by the Employer and are given for the information of the Contractor.

3.4.6 Disconnectors and Earth Switches

3.4.6.1 General

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

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

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

3.4.6.2 Operating Duty and Performance

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

b) The earth switch shall be capable of discharging trapped charges.

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

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

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

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

3.4.6.3 Constructional Features

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

General

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

Contacts

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

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

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

d) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and springs shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator/earth switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all times. Provision shall be made to adjust the contact pressure.

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

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

Base

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

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

Blades

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

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

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

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

e) The isolator/earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals.

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

Insulator

a) The insulator shall conform to IEC-60168. The porcelain of the insulator shall have minimum cantilever strength of 800kg. The insulators shall be of solid core type.

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

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

Earth Switches

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

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

c) The earth switch shall be manual operated.

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

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

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

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

Operating Mechanism

a) 145kV Isolators shall be ac motor operated, 36kV isolator and earth switches shall be manual operated.

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

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

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

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

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

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

3.4.6.4 Operation

a) The isolator and earth switch shall have individual drives for main blades. The operating mechanism of the three poles shall be well synchronized and interlocked.

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

c) Each isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator or earth switch with ease in one movement while standing at ground level. The manual operating handle shall have provision for padlocking. The operating handle shall be located at 1000 mm from the base of isolator support structure.

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

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

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

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

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

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

3.4.6.5 Tests

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

3.4.6.6 Technical Parameters

The Contractor shall determine the technical parameters of the isolators/earth switches. Ref er to Appendix-
A1 of Schedule A of volume 3 of 3 (Schedule of Requirements) for the technical parameters

of the isolators/Earthing switch generally used by the Employer and are given for the inform ation of the Contractor

3.4.7 Instrument Transformers

3.4.7.1 General

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

3.4.7.2 Technical and Constructional Requirements

The following requirements shall apply:

3.4.7.2.1 Common for all Instrument Transformers

Bushing Insulators

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

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

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

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

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

Box

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

Tank

The Instrument transformer tank alongwith top metallics shall be hot dip galvanised or paint ed.

Lifting Arrangements

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

3.4.7.2.2 Current Transformers (CT)

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

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

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

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

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

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

g) The rated extended primary current of the CT's shall be 120% of rated primary on all except (one) highest tap ratio.

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

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

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

k) Special Technical Requirements

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

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

3.4.7.2.3 Voltage Transformers

a) Voltage transformers shall be Inductive Type.

b) Each core of secondary winding to be used for protection purpose shall be protected by

MCB's of suitable rating. NO and NC contacts shall be provided on the MCB for monitoring purposes. The secondary terminals of the IVT's shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the MCB's.

c) The accuracy of metering winding shall be maintained through out the entire burden range upto total burden simultaneously on all the three windings without any adjustments during operation.

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

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

f) Special Technical Requirements

i) Transient Response

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

ii) Ferro-resonance

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

iii) Protective Device

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

iv) Power Line Carrier

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

v) Reproduction of Harmonics

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

vi) Reproduction of Transients

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

3.4.7.3 Type Tests

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

3.4.7.4 Routine Tests

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

Current Transformers

a) Measurement of capacitance

b) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/[3

c) Oil leakage test

Voltage Transformers

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

b) Sealing test as per IEC

3.4.7.5 Technical Parameters

The technical parameters shall be determined by the Contractor. Refer to Appendix-A3 of Schedule-A of volume 3 of 3 (Schedule of Requirements) for the technical parameters for Instrument Transformers generally used by the Employer and are furnished for the information of the Contractor.

3.4.8 Surge Arresters

3.4.8.1 General

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

3.4.8.2 Operating Duty and Performance

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

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

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

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

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

3.4.8.3 Constructional Features

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

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

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

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

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

3.4.8.4 Fittings and Accessories

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

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

Surge counters shall have an internal assembly which is matched to the line discharge capa bility of the arrester and shall include a leakage current meter with a bi-linear scale for ease of reading. Auxiliary contacts are to be provided to signal remote indication of counter opera tion.

3.4.8.5 Tests

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

3.4.8.6 Technical Parameters

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

3.4.9 Neutral Grounding Resistors

The earthing resistors shall be of the metal grid type with enclosure having degree of protect ion IP 33 and suitable for outdoor service on the neutral earthing system as specified. The fr amework and enclosure shall be of galvanised steel. The grids shall be adequately supporte d on steel rods and porcelain insulators and be designed to withstand the currents flowing u nder fault conditions. Adequate insulating barriers shall be provided to prevent internal flash over.

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

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

3.4.10 Busbars, Conductors and Connections

Busbars and electrical connections in outdoor substations shall be in accordance with BS 21 5, 159 and 2898 and relevant IEC standards in respect of current rating and material analysi s.

Overhead conductors carried by the switchyard structures shall be erected with such sags and tensions that when the conductors are subjected to the load combinations in Section 11, the factor of safety will not be less than 3.5.

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

3.4.10.1 Tubular Bus Conductors

General

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

Constructional Features

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

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

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

Parameters

The size and other parameters of tubular bus conductors suitable for the busbar specificatio n stated in Appendix A in Volume 3 of the bid document shall be determined by the Contract or.

Tests

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

3.4.10.2 Flexible Bus-Bars and Earthwire

General

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

Constructional Features

a) Workmanship

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

b) Joints in Wires

No joints shall be permitted in the individual wires in the outermost layer of the finished conductor. However, joints in the inner layers of the conductor shall be allowed but these joints shall be made by cold pressure butt-welding and shall be such that no two such joints are within 15 metres of each other in the complete stranded conductor.

c) Materials

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeds 0.04%.

Parameters

The size, rating, number of conductors per phase and the configuration, etc. shall be determ ined by the Contractor.

Tests

The following type, acceptance and routine tests and tests during manufacture shall be carri ed out on the conductor in addition to the tests specified in relevant applicable standards.

a) Type Test

DC Resistance Test on Stranded Conductor On a conductor sample of minimum 5 m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by Kelvin double bridge by placing the clamps initially zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20 0C as per relevant IEC Standard.

b) Acceptance Test

i) Visual and Dimensions check on Drums

ii) Visual Check for Joints, Scratches etc.

iii) Dimensional check on Aluminium Strands

iv) Check for lay-ratios of various Layers The following tests shall be conducted once on sample/samples of conductor.

- Breaking load test on aluminium strands

- Wrap load test on aluminium strands

- DC resistance tests on aluminium strands

All the above tests shall be carried out on aluminium strands after stranding only.

c) Routine Tests

i) Check to ensure that the joints are as per specification.

ii) Check that there are no cuts, fins, etc. on the strands.

iii) Check that drums are as per specification.

iv) All acceptance tests as mentioned above are to be carried out on each coil

d) Tests During Manufacture

Chemical Analysis of Aluminium used for making aluminium strands Samples taken from the aluminium ingots/coils/ strands shall be chemically/spectrographically analyzed. The same shall be in conformity to the specified requirements.

e) Packing

The conductor shall be supplied in strong wooden drums constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The drums shall generally conform relevant IEC/Standard. Only one length of conductor shall be wound on each drum.

3.4.10.3 Clamps & Connectors

General

a) Conductor clamps shall be compression type except for shield wire in accordance with BS 3288 and shall be made of materials listed below :

For connecting ACSR conductors: Aluminium alloy casting
For connecting equipment terminals made of copper with ACSR conductors: Bimetallic connectors made from aluminium alloy casting with 2mm thick Bimetallic liner
For connecting G.I. Shield wire : Galvanised mild steel
Bolts, nuts & Plain washers: Electro galvanised for sizes below M12, for others hot dip galvanised
Spring washers: Electro-galvanised mild steel suitable

b) Equipment shall be supplied with the necessary terminals and connectors, as required by the ultimate design for the particular installation. The conductor terminations of equipment shall be either expansion, sliding or rigid type. The requirements regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. In case the connector is not available then equivalent connector may be used. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included under this scope of Work.

c) Where copper to aluminium connections are required, bi-metallic clamps shall be used, which have been properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress. The design details of joint shall be furnished to the Employer.

d) Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified are also included in the scope of Work.

e) No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2mm thickness shall be cast integral with aluminium body for Bi-metallic clamps. When copper alloy is not cast integral with aluminium body, a bimetallic washer or strip shall be used to meet the functional requirement.

f) All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

g) Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of IPS Aluminium tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

h) Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

i) All current carrying parts shall be designed and manufactured to have minimum contact resistance.

Constructional Feature

All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edge s and corners shall be blurred and rounded off. Size of the terminal/connector for which the clamp/ connector is suitable shall be embossed/punched (i.e. indelibly marked) on each co mponents of the clamp/connector, except on the hardware. The clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/ connector is designed with respect to the specified reference ambient temperature, s hall also be indelibly marked on each component of the clamp/connector, except on the har dware. All current carrying parts shall be designed and manufactured to have minimum cont act resistance. The Corona extinction voltage for 400 kV and 230 kV class clamps shall not be less than 320 kV and 156 kV respectively.

Tests

The clamps and connectors shall be subject to type and routine tests as per relevant IEC Standard. Type tests as per IEC Standard shall be carried out on one sample of each type and design. One sample of each type and design shall also be type tested for:

a) Temperature rise test

b) Short time current test

c) Dry corona and RIV test

d) Resistance test and tensile test

3.4.10.4 Spacers

General

The spacers shall conform to relevant IEC/ BS Standard.

Constructional Features

No magnetic material should be used in the fabrication of the spacers except for the GI bolts and nuts. Spacer design shall be made to take care of fixing and removing during installation and maintenance. The design of spacer shall be such that the conductor does not come in contact with any sharp edge.

Tests

The spacers shall be subjected to the type tests, acceptance tests and routine tests in accordance with relevant IEC/BS Standard.

3.4.11 Insulators, Bushings, Buses and Hardware

3.4.11.1 Bushings and Support Insulators

General

Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-60233. The support insulators shall be manufactured and tested as per IEC-60168, IEC-60273. The insulators shall also conform to IEC-60815 as applicable. All bushings shall be one piece only and no joints shall be accepted.

Constructional Features

a) Porcelain used shall be homogeneous and free from imperfections that might affect the mechanical or dielectric quality.

b) Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. The ground surface shall not be glazed.

c) Condenser type bushing shall be provided with :

    i) Oil level gauge.

    ii) Oil filling plug and drain valve if not hermetically sealed.

    iii) Tap for capacitance and tan delta test.

d) When bushings have an under-oil end of re-entrant form, the pull through lead shall be fitted with a gas bubble deflector.

e) Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

f) Bushings of identical rating shall be interchangeable.

g) No arching horns shall be provided on the bushings.

h) All ferrous parts shall be hot dip galvanized or zinc plated and passivated. All joints shall be air tight. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

i) Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they shall be used.

j) When operating at rated voltage there shall be no electric discharge between conductor and insulators which would cause damage to conductors or insulators by the formation of substances produced by chemical action. No radio interference shall be caused when operating at rated voltage.

k) The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

l) The Bidder/Contractor shall define the type of insulator (type A or B) as per IEC-60168.

m) Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

n) Special precaution shall be taken to exclude moisture from paper insulation during manufacture, assembly, transport and erection. The surface of all paper insulation shall be finished with non-hygroscopic varnish which can not be damaged easily.

o) Each porcelain insulator shall have marked upon it the manufacturer's name or identification mark and year of manufacture. These marks shall be clearly legible after assembly of fittings and shall be imprinted before firing, not impressed. Each complete bushing shall be marked with the manufacturer's name or identification mark, year of manufacture, serial number, electrical and mechanical characteristics in accordance with IEC 60137:1973.

Parameters

The parameters shall be determined by the Contractor, however the minimum performance parameters for the 132kV class post insulator shall be as per the stipulation of Schedule-A of Volume 3 of 3(Schedule of Requirements).

Tests

Each type of bushing and insulator shall be subjected to type and routine tests in accordance with applicable standards and acceptance test shall include one minute dry power frequency withstand test and ultrasonic test (except for hollow insulator). The ultra sonic test shall be done on the porcelain before assembly. All sample tests and special tests shall also be conducted.

3.4.11.2 String Insulators & Hardware

General

The insulators for suspension and tension strings shall conform to relevant IEC/Standard. Insulator hardware shall conform to relevant IEC/Standard. The insulation levels shall be determined by the Contractor but the minimum performance characteristics shall be as specified in Schedule A of Volume 3 of 3.

Constructional Features

a) Requirements specified in Clause 3.4.11.1 above shall also be applicable equally to string (disc) insulators.

b) Suspension and tension insulators shall be wet process porcelain with ball and socket connections. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength markings on porcelain printed and applied before firing.

c) Insulator hardware shall be uniform to the requirements stipulated for clamps and connectors under Clause 3.4.10.3.

d) Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating condition.

e) Insulator hardware assembly shall be designed as per the design requirement but for at least 4000 Kg. tensile load per phase for the switchyard with a factor of safety two (2). Similarly ground wire tension clamp shall be designed for at least 3500 kg tensile load with a factor of safety of two (2).

f) Tension string assembly shall be supplied along with suitable turn buckle (one turn buckle per string).

g) All hardware shall be bolted type.

h) As an alternative to disc insulator string, the Bidder/Contractor can provide a combination of long rod insulators, with suitable hardware. This combination shall be suitable for application specified and should offer the same equivalent parameters as would be available from the insulator string composed of specified disc insulators and hardware combination. Further the complete long rod insulator string shall be subject to the specified tests and the insulator shall also be subject to all tests as per relevant standards. All other constructional features specified above shall also apply to the long rod insulator string.

<u>Parameters</u>

The minimum parameters of insulator discs/complete insulator strings shall be as per the stipulation of Schedule-A of Volume 3 of 3(Schedule of Requirements).

<u>Tests</u>

The insulators for suspension and tension strings and hardware shall be subjected to the following type tests, acceptance tests and routine tests.

a) Type Tests on Insulator Strings:

   i) Dry and Wet Power Frequency Voltage withstand test with corona control rings and arcing horns

   ii) Dry and Wet Switching surge voltage withstand test with corona control Ring

   iii) Dry and Wet Impulse Voltage Withstand test with corona control rings

   iv) Voltage distribution test

   v) Corona and RIV test (Dry Condition)

   vi) Mechanical strength test

b) Type Tests on Disc Insulators:

i) Thermal and Mechanical performance tests

ii) Power frequency puncture withstand voltage

iii) Steep front wave test to be conducted as follows:

- This test shall be performed on five samples taken at random
- The insulators shall be subjected to five(5) positive and five (5) negative impulses with wave fronts of at least 2500 kV/microsecond
- In the case of low flashover values of porcelain puncture, the number of samples shall be doubled or another test shall be performed.

iv) Results of the second test should not show porcelain puncture

c) Acceptance Tests for Disc Insulators:

i) Visual examination

ii) Verification of Dimensions

iii) Temperature Cycle Test

iv) Puncture Test

v) Galvanizing Test

vi) Mechanical performance Test

vii) Test on locking device for ball and socket coupling

viii) Porosity test

ix) Electromechanical test

d) Type Test on Hardware Fittings Only:

i) Magnetic power loss test for suspension assembly (For both suspension and drop clamps)

e) Acceptance Test on Hardware Fitting:

i) Visual Examination

ii) Verification of Dimensions

iii) Galvanizing/Electroplating tests

iv) Slip strength test

v) Shore hardness test for Elastometer (if applicable)

vi) Mechanical strength test for each component (including corona control rings and arcing horns)

vii) Mechanical strength test on corona control rings

viii) Test on locking devices for ball and socket coupling

f) Routine Test on Disc Insulator/Long Rod Insulator:

i) Visual Inspection

ii) Mechanical Routine Test

iii) Electrical Routine Test

g) Routine Test of Hardware Fittings:

i) Visual examination

ii) Mechanical strength test

h) Test During Manufacture on all Components as Applicable on Disc Insulator:

i) Chemical analysis of zinc used for galvanizing

ii) Chemical analysis, mechanical hardness tests and magnetic particle inspection for malleable casting

i) Test During Manufacture on all Components as Applicable on Hardware Fittings:

i) Chemical analysis of zinc used for galvanizing

ii) Chemical analysis, mechanical hardness tests and magnetic particle inspection for forgings.

iii) Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricated hardware.

<u>Test Procedures</u>

a) Voltage Distribution Test(Dry)

The string shall be energised with 100 kV power frequency voltages. The voltage across each insulator unit shall be measured by using a high impedance voltmeter. The voltmeter shall be calibrated before and after the measurement. The voltage across any disc shall not exceed 9% of the applied voltage for single and double suspension insulator string and 10% for double tension insulator strings.

b) Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall be as per relevant IEC standard. There shall be no evidence of corona on any part of the sample when all possible sources of corona are photographed in a darkened room.

c) RIV Test (Dry)

Under the conditions as specified under b) above the insulator string along with complete hardware fittings, RIV test shall be done and the test procedure shall be in accordance with IEC-60437-1973.

d) Mechanical Strength Test

The complete insulator string along with its hardware fittings shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

e) Magnetic Power Loss Test for suspension assembly (for both drop and suspension clamp)

Two hollow aluminium tubes of 32 mm dia. shall be placed 450 mm or 250 mm apart depending upon the voltage level at which test is to be done. An alternating current in the range of 200 to 600 Amps. shall be passed through each tube. The reading of the wattmeter with and without two suspension assemblies along with the line side yoke plate clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for the suspension assembly shall be plotted for each value of current. The value of loss corresponding to 300 Amps shall be read from the graph. The magnetic power loss of the clamp assembly with entire line fitting shall not exceed 4 watts at 600 Amps current (rms).

f) Mechanical Strength Test of each component

The load shall be so applied that the component is stressed in the same way as it would be i n actual service and the procedure as given in f) above should be followed.

g) Chemical Analysis of Zinc used for galvanizing

Samples taken for the zinc ingot shall be chemically analyzed as per relevant IEC Standard. The purity of zinc shall be not less than 99.5%.

h) Test for Forgings, Castings & Fabricated Hardware

The chemicals analysis, mechanical hardness tests and magnetic particle inspection, shall be as per the internationally recognized procedures for these tests. The sampling shall be based on heat number and heat treatment batch. The details regarding test shall be mutually agreed to by the Contractor and the Employer.

3.4.12 Interlocking Facilities

Disconnectors, earthing switches, circuit breakers, etc., shall be provided with an interlockin g system which ensures safe operation of the equipment under all service conditions.

The interlocking scheme shall be designed for the final substation arrangement. The items o f plant supplied under this Contract shall be complete with all interlocking facilities needed fo r the final arrangement, avoiding the need for future modifications.

Where mechanical key interlocks are employed, they shall be effective at the point where ha nd-power is applied so that stresses cannot be transferred to parts remote from that point.

Tripping of the circuit-breaker shall not occur if any attempt is made to remove a trapped ke y from the mechanism. Emergency tripping devices shall be kept separate and distinct from any key interlocking system and shall be clearly labelled, suitably protected from inadvertent operation but readily accessible.

Circuit-breakers shall be interlocked so that, except under maintenance conditions, it is not possible to close a circuit-breaker unless the selected busbar and circuit disconnectors are c losed.

Except as stated below, disconnectors shall be so interlocked that they cannot be operated unless the associated circuit-breaker is open. Where power transformers are banked together, the individual transformer disconnectors shall be interlocked so that it is not possible to make or break load current at the disconnectors.
Provision for on load transfer of feeder circuits from one busbar to another shall be made po ssible by interlocks which ensure that the section disconnectors, bus coupler and its disconn ectors are closed.

All electrical interlocks shall so function as to interrupt the operating supply, and an approve d system of interlocks shall be provided which shall cover the emergency hand operation of apparatus which is normally power operated. Failure of supply (or its restoration after an out age) or of connections to any electrical interlock shall not produce or permit faulty operation. Electrical bolt interlocks shall be energized only when the operating mechanism is being op erated. Visible indication shall be provided to show whether the mechanism is locked or free . Approved means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

3.4.13 Auxiliary Switches and Contactors

Circuit-breakers, disconnectors and earthing devices and circuit selector disconnectors shall be provided with suitably rated auxiliary switches and contactors, where permitted, to relay circuit information for the purpose of control, protection, indication and metering at the subst ation site as required by the relevant section of the Specification. In addition they shall be pr ovided with auxiliary contacts for position indication to the central system control room via th e remote supervisory system. Disconnector auxiliary switches are not to be used for current transformer switching circuits.

Auxiliary contactors shall be provided only where the circuit requirement cannot be met by t he auxiliary switch arrangements and multiple contactors and relays will not be accepted in l ieu of the auxiliary switches except as specifically approved by the Engineer. Auxiliary switc hes and contactors shall comply with the requirements of this Specification and in particular shall be capable of operation within the same voltage limits as specified for the associated ci rcuit-breaker close and trip coils.

The connections of all auxiliary switches, including spares, and contactors as well as the as sociated coil connections and interconnections between auxiliary switches, shall be wired to a terminal board located in the operating cubicle or other approved position.

Auxiliary switches and contactors shall be mounted in an approved accessible position clear of the main operating mechanism but with a minimum of additional mechanical linkages and housed in a substantial weatherproof enclosure. Where adjustable linkages are provided to facilitate the timing of the auxiliary switches with respect to the main equipment, approved locking devices shall be fitted.

Auxiliary switch contacts shall be positively operated, make with a wiping action and, where necessary, discharge resistors shall be provided to prevent arcing when breaking inductive circuits.

Except for the contacts employed for control and interlocking, the requirements for auxiliary switches in respect of timing shall be as follows:-

For Circuit-Breakers

Normally open contacts, with the exception of two sets of this type, shall close in about 10 milliseconds after the making of the main circuit-breaker contacts and shall open in about 10 milliseconds before the separation of the main circuit-breaker contacts whilst the two remaining sets shall close in about 5 milliseconds before the making of the main circuit breaker contacts and open simultaneously with the main circuit contacts.

Normally closed contacts shall close 10 milliseconds after the opening of the main circuit-breaker contacts and open at least 10 milliseconds before the making of the main circuit-breaker contacts.

For Busbar Disconnectors

The operating sequence of any disconnector auxiliary switches used in D.C. circuits for high impedance busbar zone protection shall be such that the auxiliary switches operate:-

a) before reaching the pre-arcing distance on closing the disconnector.

b) after the pre-arcing distance has been exceeded on the opening of the disconnector.

Auxiliary switches shall be adjustable from normally-open to normally-closed or vice-versa.

For Line Disconnectors

As for Busbar disconnector auxiliary switches.

For Earthing Switches

As for Busbar disconnector auxiliary switches.

3.5 Indoor Metal Clad Switchgear and Construction Requirement

3.5.1 deleted

3.6 Interference with Existing Equipment

Work carried out on site in extending equipment or modifying the existing substation shall be so arranged as to cause minimum interference with existing plant and equipment and interruption to supplies. The Contractor shall include in his price for the provision, erection, commissioning and subsequent dismantling and removal from site of any temporary structures, insulators and connections that may be necessary to maintain continuity of supply whilst certain sections of the plant are out of service to permit the execution of the Works.

If it is necessary to reposition any of the existing substation plant in order to incorporate the specified works or to comply with specific requirements, all costs incurred in dismantling, removing, modifying, repositioning, existing and commissioning of such equipment shall be deemed to have been included in the Bid Price.

The repositioning of any plant is subject to the specific approval of the Employer. Existing plant rendered redundant by this Contract shall remain the property of the Employer and shall be returned to the Employer's store.

Permission for access to existing substations to execute the Works shall be obtained in writing from the Employer. The Contractor shall conform to the Employer's Safety Rules in all respects when working in or near existing plant.

Extensions at the existing substation shall be carried out maintaining the same busbar centres, heights etc., other essential dimensions and interlocking schemes.
Where stated in the Schedule of Requirements, equipment for existing substations shall be of the same type and and manufacture as that already in service.

SECTION 4

TRANSFORMERS

TABLE OF CLAUSES

SECTION 4

POWER TRANSFORMERS

4.1 SCOPE

These clauses describe the General Technical Requirements for Power Transformers and shall be read in conjunction with the Requirements in Volume 3 of 3.

“Installation, testing & commissioning of power transformer shall be done by the transformer engineer(s) of the power transformer manufacturer(s).”

4.2 REFERENCES

4.2.1 IEC Standards

IEC 60044	Instrument transformers-Part 1: Current transformers
IEC 60044	Instrument transformers-Part 2: Inductive volatage Transformers
IEC 60060	High voltage testing techniques (Part 1 & 2)
IEC 60099	Surge arrestors (Part 4 & 5)
IEC 60076	Power transformers (Parts 1, 2, 3, 4, 5, 6, 7, 8 & 10)
IEC 60137	Insulated bushings for alternating voltages above 1000V
IEC 60214	Tap changers (Parts 1 & 2)
IEC 60228	Conductors of insulated cables
IEC 60270	Recommendation for partial Discharge measurements
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60422	Supervision and maintenance guide for mineral insulating oils in electrical equipment
IEC 60439	Low voltage switchgear and controlgear assemblies (Parts 1 & 2)
IEC 60529	Degrees of protection provided by enclosures
IEC 60815	Guide to the selection of insulators in respect of polluted condition

4.2.2 British Standards

BS 61	Specification for threads for light gauge copper tubes and fittings
BS 381C-1996	Color Standards for General Purpose
BS 729	Hot Dip Galvanizing
BS 2569-2	Cleaning Before Painting
BS 3600	Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes
BS 4504	Circular flanges for pipes, valves and fittings (PN designated)
BS 5493	Code of practice for protective coating of iron and steel structures against corrosion
BS 6121	Mechanical cable glands
BS 6346	Specification for PVC insulated cables for electricity supply
BS 6435	Specification for unfilled enclosures for the dry termination of HV cables for transformers and reactors

BS 7354 Code of practice for design of HV open terminal stations

4.2.3 BS European Standards

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

4.3 POWER TRANSFORMERS

4.3.1 Types of Transformer and Operating Conditions

i) General

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076, Parts 1 to 8 & 10 inclusive.

Electrical clearances shall not be less than as stated in the Project Requirements in Volume 1, whichever is the greater.

ii) Cooling

The types of cooling shall be as stated in the Schedule A of Requirements and the letters relating to the method of cooling used in this Specification and Schedules shall be in accordance with IEC 60076.

Where a combination of three/two methods of cooling is applied to one transformer, as for ONAN/ONAF units for 230/138/33kV transformer and ONAN/ONAF units for 132/33 kV transformer, the transformer shall be capable of operating under the ONAN condition as stated in the Schedule of Requirements, after which the cooling equipment is to come into operation and the Transformer will operate as an ONAF unit.

Failure of one fan shall not reduce the continuous maximum rating of the transformer.

iii) Parallel Operation

Transformers supplied against each item shall be designed to operate satisfactory, one with the other, when operating on the same tap position.

iv) Handling on Site

For installation purposes and to permit the moving of transformer, the transformers are to be equipped with castors (rail wheels). A permanent rail transfer track system shall be provided, integrated with the transformer foundations. The castors should be able to swivel in both the longitudinal and transverse directions.

A system of wedges shall be included to stop any unwanted movement of the transformer during its operating life. The distance between rails must be compatible with the transformer dimensions and also the rail gauge prevailing at existing substation sites.

4.3.2 Continuous Maximum Rating

Transformers shall have the rating stated in the Schedule of Requirements and shall comply with the requirements as regards temperature rise and overloads on all tappings, irrespective of the direction of power flow and with the voltage of the lower voltage winding at the normal voltage stated in the Schedule of Requirements. To allow for high atmospheric temperatures, the allowable temperature rises shall be reduced in accordance with IEC 60076-2.

The overload capability shall be in accordance with IEC 60076-7.

4.3.3 Electrical Connections

Transformer windings shall be connected in accordance with the Vector group symbol specified in the Schedule of Requirements and as per IEC 60076.The neutral point of star connected winding shall be brought out for grounding.

All electrical connections within windings shall be brazed but, subject to approval, mechanically crimped joints may be used for round stranded conductors on tapping, bushing or earthing connections and on bundle conductors where design has been proved by type test and application is subject to rigorous quality control.

4.3.4 Ability to Withstand Short Circuit

i) General

All transformers shall be capable of withstanding, on any tappings and without damage, the thermal and dynamic effects of external short circuits under the conditions stated in IEC 60076 Part 5. For this purpose the design short circuit level for each system voltage is stated in the Schedule of Requirements.

ii) Calculations and Tests

Evidence shall be submitted with the Tender as to the extent to which the manufacturer has proved, or is able to prove, either by calculation or test, the ability of the specified Transformers to withstand short circuit.

The Bidder shall provide with his Tender a brief description of those transformers, or parts thereof, which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers tendered but, in the event this is not so, the Engineer reserves the right to require calculations to prove that the design of transformers tendered will satisfactorily comply with this Clause.

4.3.5 Losses and Evaluation of Losses

Guaranteed values for component losses of the total loss which shall be as low as is consistent with transport restrictions, reliability and economic use of materials, shall be as stated in the Schedule E of Particulars and Guarantees.

Tenders will be assessed on the basis of the least 'Present Worth' of capital cost plus guaranteed losses, being the sum of the installed Tender Price of the transformers plus a sum which shall be:-

For each unit of the three-phase 230/132/33kV, 225/300 MVA (ONAN/ONAF) power transformer,

Evaluated price of transformer loss = N.a + L.b + M.c

Where	N	=	No load loss (core-loss) at rated voltage in kW
	L	=	Load loss (copper-loss) at 75°C, 50 Hz maximum continuous rating in kW
	M	=	Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
	a	=	Cost/kW of no load loss (core-loss) valued at Taka 600,000.00
	b	=	Cost/kW of load loss (copper-loss) valued at Taka 300,000.00
	c	=	Cost/kW of auxiliary power valued at Taka 300,000.00

For each unit of the three-phase 132/33 kV, 50/75 MVA (ONAN/ONAF) power transformer,

Evaluated price of transformer loss = N.a + L.b + M.c

Where	N	=	No load loss (core-loss) at rated voltage in kW
	L	=	Load loss (copper-loss) at 75°C, 50 Hz maximum continuous rating in kW
	M	=	Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
	a	=	Cost/kW of no load loss (core-loss) valued at Taka 112,000.00
	b	=	Cost/kW of load loss (copper-loss) valued at Taka 58,000.00
	c	=	Cost/kW of auxiliary power valued at Taka 58,000.00

The acceptance of transformers yielding component losses higher than the guaranteed values shall be governed by either of the following:-

(a) Component losses in excess of guaranteed values but within the tolerance permitted under IEC 60076 Part 1.

Transformers shall be acceptable subject to full compliance with all technical particulars, including temperature rises at CMR and subject to the Bidder accepting deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above evaluation rates.

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

The acceptance of transformers shall be entirely at the discretion of the Employer and subject to the Bidder accepting the deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above loss evaluation rates.

In the event of transformers yielding component and total losses which are either equal to or below the guaranteed values, the Bidder will not be entitled to any premium in respect of reduction in losses below the guaranteed values.

4.3.6 Impedance

The value of impedance measured on various tappings shall be as stated in the Schedule and minimum and maximum values where stated in the Schedule A of Requirements shall be guaranteed by the Contractor.

4.3.7 Noise

The transformer noise levels shall be measured as a type test and in accordance with IEC 60076-10. The acceptance level of the transformers shall be as stated in the Schedule of Requirements.

4.3.8. Harmonic Suppression

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

4.4 MAGNETIC CIRCUIT AND WINDINGS

4.4.1. Magnetic Circuit

The core winding structure and major insulation shall be such as to permit an unobstructed flow of cooling oil over the core and through the core cooling ducts to ensure efficient cooling of the core and where required of flux shunts and tie rods/bars.

The magnetic circuit shall be insulated from core bolts and supporting frame work and be capable of withstanding a test voltage to core bolts and to the frame of 2.5 kV r.m.s for one minute. Two separate insulated removable bolted earthing links shall be provided for earthing of the core and of the core-supporting framework to the exterior of the tank. These links shall be located in a covered box at the top of the transformer and arranged so they are accessible for testing purpose without opening up the transformer. Alternatively connection to both the core and the frame may be made via two externally bolted links within an access box fitted with an oil tight cover near the base of the tank.

The core shall be earthed via copper straps inserted in each group of core packets separated by oil ducts or other insulating materials: and at a minimum of four (4) points distributed evenly across the width of the core.

4.4.2 Flux Density

Cores shall be constructed from cold rolled grain oriented steel sheets. Design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, and that when operating under the most onerous conditions envisaged in IEC 60076 and IEC 60354, flux density in any part of the magnetic circuit does not exceed 1.9 Tesla.

4.4.3 Windings

i) Construction of Windings

Transformer star connected windings shall have graded insulation as defined in IEC 60076. For 34.5 kV and below they shall have uniform insulation as defined in IEC 60076. All neutral points shall be insulated to withstand the applied test voltage specified in the Schedule of Requirements.

The windings shall be located in a manner which will ensure that they remain electromagnetically balanced and that their magnetic centres remain coincident under all conditions of operation.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure for such length of time as will ensure that further shrinkage will not occur in service.

The windings and leads of all transformers shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other transient service conditions including external short circuit.

If the winding is built up of sections or of disc coils separated by spacers, the clamping arrangements shall ensure that equal pressures are applied to all columns of spacers.

ii) Tertiary Windings

The tertiary winding of 230/138/33kV power transformer shall be adequately rated for the specified load and its average and hot spot winding gradients at the specified load shall not exceed the specified temperature rise for winding average and winding hot spot when added to the mean oil and top oil temperature rises measured during the temperature rise test on the HV and LV temperature rise tests.

The tertiary winding shall further have adequately conductor cross sectional area and mechanical strength to withstand a through fault on the tertiary terminals and the fault current present in that winding during line to ground fault on the HV and LV phase terminals and without exceeding the maximum permitted current density and temperature rise limits calculated in accordance with IEC 60076-5 Clause 4.1.4.

4.4.4 Internal Earthing

i) General

All metal parts of the transformer, with the exception of the individual core laminations, core bolts and associated individual clamping plates, shall be maintained at some fixed potential.

ii) Earthing of Core Clamping Structure

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

(a) by connection through vertical tie rods to the top structure;

(b) by direct metal-to-metal contact with the tank base maintained by the weight of the core and windings;

(c) by connection to the top structure on the same side of the core as the main earth connection to the tank.

iii) Earthing of Magnetic Circuits

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath an inspection opening in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2.5 kV. The link shall have no detachable components and the connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

All insulating barriers within magnetic circuits shall be bridged by means of aluminium or tinned copper strips, so inserted as to maintain electrical continuity.

iv) Earthing of Coil Clamping Rings

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the Transformer as the main earth connection.

v) Size of Earthing Connections

Main earthing connections shall have a cross-sectional area of not less than 80 sq.mm but connections inserted between laminations may have cross-sectional areas reduced to 20 mm^2 when in close thermal contact with the core.

4.5 TANKS AND ANCILLARY EQUIPMENT

4.5.1 Transformer Tanks

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable structural steel of an approved grade to BS EN 10029. The final coat colour of transformers shall be to Munsell 5Y-7/1. The On-load tap changer tank shall be separated from the main tank of the transformer.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Each tank shall be provided with at least four jacking lugs, and where required, with lugs suitably positioned for transport on a beam transporter. Haulage lugs should also be provided to enable a cable to be used safely for haulage in any direction.

The transformer tank shall be capable of withstanding a full vacuum when empty of oil, without any significant permanent deformation or damage.

All joints, other than those which may have to be broken, shall be welded.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Where cooling tubes are used, each tube shall be of heavy gauge steel welded into the tank sides, top and bottom.

Each tank cover shall be of adequate strength, must not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. Inspection openings shall be provided to give access to the internal connections of bushings, winding connections and earthing links. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection covers shall be provided with lifting handles.

It must be possible to remove any bushing without removing the tank cover.

Pockets shall be provided for a stem type thermometer and for the bulbs of temperature indicators where specified. These pockets shall be located in the position of maximum oil temperature and it must be possible to remove any bulb without lowering the oil level in the tank. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

A ladder shall be provided on one side of the tank as a means for inspection and access to the top of the transformer. The lower section of the ladder shall be equipped with a barrier complete with provision for locking with a padlock.

4.5.2 Conservator Tanks, Breathers and Air Dryers

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system (see also Clause 4.6.1). Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservator tanks shall also be provided with a cleaning door, filling cap, drain valve with captive cap and an oil level indicator with minimum and maximum levels indicated. The normal level at an oil temperature of 25°C shall be indicated and the minimum and maximum levels shall also be correlated with oil temperature markings. The temperature markings shall preferably be integral with the level indicating device.

The pipework between the conservator and the transformer tank shall comply with the requirements of Clause 4.6.1 and a valve shall be provided at the conservator to cut off the oil supply to the tank.

The conservator shall be fitted with an air cell which shall be connected to a silica gel breather of a type which permits the silica gel content to be removed for drying. Due to the climatic conditions at site, this breather shall be larger than would be fitted for use in a temperate climate. All breathers shall be mounted at a height of approximately 1400 mm above ground level.

A completely separate conservator shall be provided for the OLTC. This conservator shall be fitted with: an oil level gauge, a desiccant breather, isolating valves shall be provided for connection from OLTC conservator connection pipe to OLTC and to connection breather, an oil sump drain valve for sump, a filling cap and a removable end plate for inspection and repainting.

4.5.3 Valves

Each transformer shall be fitted with the following valves as a minimum requirement:-

Main Tank

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

(B) One 50 mm bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against (A). Where design permits, this valve may be combined with item (C).

(C) One 50mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable. This valve shall also be provided with an approved oil sampling device.

(D) One valve between the main tank and gas actuated relay, complete with bypass facility to facilitate removal of relay and maintain oil flow.

Conservator

(E) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank complete with bypass pipe work for Buchholz relay to facilitate maintenance of the relay.

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

Tap Changer

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

Diverter Switch Tank

(H) One drain valve to be fitted to each tank.

Radiators and Cooler Banks

(I) Valves at each point of connection to the tank and in accordance with Clauses 4.6.2 and 4.6.3.

The two valves (D) and (E) arrangement across the gas actuated relay are to be connected with a oil pipe work bypass facility to facilitate removal of the relay, due to failure etc, and still maintain the oil flow system between the conservator and main tank.

Blank flanges, plates or captive screw caps shall be fitted to all valves and pipe ends not normally connected in service.

The omission of any, or the provision of alternative arrangements to the above requirements, will not be accepted unless approved in writing by the Employer before manufacture.

4.5.4 Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil resisting synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork, or similar material, or where metal inserts are provided to limit compression.

Gaskets shall be as thin as possible consistent with the provision of a good seal and full details of all gasket sealing arrangements shall be shown on the Plant drawings.

4.5.5 Pressure Relief Device

An approved pressure relief device of sufficient size for the rapid release of over pressure that may be generated in the tank, and designed to operate at a static pressure lower than the hydraulic test pressure, shall be provided. It shall be of the spring operated valve type ("Qualitrol" or equivalent) and shall be provided with one set of normally open signaling contacts which will be used for trip alarm purposes.

The relief device is to be mounted on the tank cover and is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation. Discharge of oil shall be directed away from the transformer top cover and clear of any operating position.

4.5.6 Earthing Terminals

Two substantial steel flag type terminals having two 14mm diameter holes on 55mm centres shall be located one on either side and near to the bottom of the transformer to facilitate connection to the local earthing system.

4.5.7 Rating, Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to each transformer tank at an average height of 1500mm above the ground level:-

(A) A rating plate bearing the data specified in IEC 76 Part 1. This plate shall also include the short-circuit current rating and time-factor for each winding.

(B) A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 76 Part 1 with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct physical relationship of the terminals.

(C) A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.

Plates are to be of stainless steel or other approved material capable of withstanding the rigours of continuous outdoor service at site.

4.5.8 Nuts & Bolts of Transformer Tanks

All nuts & bolts of transformer shall be stainless steel.

4.6 COOLING PLANT

4.6.1 Cooling Plant General

Radiators and coolers shall be hot-dip galvanized, designed so that all painted surfaces can be thoroughly cleaned and easily painted in situ with brush or spray gun. The design shall also avoid pockets in which water can collect and shall be capable of withstanding the pressure tests specified in Section 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) A valve at each point of connection to the tank.
(B) A valve at each point of connection of radiators.
(C) Loose blanking plates for blanking off the main oil connections.
(D) A 50mm filter valve at the top of each cooler bank.
(E) A 50mm drain valve at the lowest point of each interconnecting oil pipe.
(F) A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.
(G) Air release and drain plugs on each radiator.

The omission of any or the provision of alternative, arrangements to the above requirements will not be accepted unless approved in writing by the Engineer before manufacture.

4.6.4 Forced Cooling

The type of forced cooling shall be as stated in the Schedule of Requirements.

Forced cooling equipment for transformers of similar rating and design shall be completely interchangeable, one with the other, without modification on Site.

4.6.5 Oil Pipes and Flanges

All oil piping necessary for the connecting of each transformer to its conservator, cooler banks etc. shall be supplied and erected under this Contract.

The oil piping shall be of approved material with machined flanged joints. Copper pipework is to comply with BS 61.

Dimensions of steel pipes shall be in accordance with BS 3600 and the drilling of all pipe flanges shall comply with BS 4504.

An approved expansion piece shall be provided in each oil pipe connection between the transformer and each oil cooler bank.

All necessary pipe supports, foundation bolts and other attachments are to be provided.

It shall be possible to drain any section of pipework independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

4.6.6 Air Blowers

Air blowers for forced air cooling shall be of approved make and design and be suitable for continuous operation out-of-doors. They shall also be capable of withstanding the stresses imposed when brought up to speed by the direct application of full line voltage to the motor.

To reduce noise to the practical minimum, motors shall be mounted independently from the coolers or, alternatively, an approved form of anti-vibration mounting shall be provided.

It shall be possible to remove the blower, complete with motor, without disturbing or dismantling the cooler structure framework.

Blades shall be of material subject to approval.

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

Galvanized wire guards with mesh not exceeding 12.5mm shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts can not be touched by test fingers to IEC 60529.

4.6.7 Cooler Control

Where forced cooling using multiple small single-phase motors is employed, the motors in each cooling bank shall be grouped so as to form a balanced three-phase load.

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this Contract for automatic starting and stopping from contacts on the winding temperature indicating devices as specified. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor, or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totaling more than 15 kW simultaneously, either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts which may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk, together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors, shall be included in the Contract.

An alarm of indicating “Transformer Cooling Fault” is to be provided and initiated in the event of any ventilation/cooling motor trip, or failure of either main or control supplies.

4.7 VOLTAGE CONTROL

4.7.1 General

Transformers shall be provided with tap changers for varying the effective transformation ratio. Control schemes of on load tap change shall utilize 110V ac centre tap earthed voltage derived from the 415V, 3 phase, 4 wire system. Phase failure relays shall be provided to ensure a secure supply.

Number and range of taps shall be as called for in the Schedule A of Requirements.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.

Tap positions shall be numbered consecutively, ranging from one upwards. The tap positions shall be numbered so that by raising the tap position the LV voltage is increased.

4.7.2 On-Load Tap Changers

i) General

On-load tap changers shall be MR Germany or ABB Sweden make and comply with IEC 60214 and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with these standards will be accepted.

Current making and breaking switches associated with the tap selectors or otherwise where combined with tap selectors shall be contained in a tank in which the head of oil is maintained by means completely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, detection of oil surges and provision of alarm or trip contacts will be dependent on the design of tap-changer and be to the approval of the Engineer.

ii) Mechanisms

The tap change mechanism shall be designed such that when a tap change has been initiated, it will be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement not being completed an approved means shall be provided to safeguard the transformer and its auxiliary equipment.

Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions. For on-load tap change equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

Thermal devices or other approved means shall be provided to protect the motor and control circuit.

A permanently legible lubrication chart shall be provided and fitted inside the tap change mechanism chamber.

iii) Local and Remote Control

Equipment for local, manual and electrical operation shall be provided in a cubicle complying with Section 2. A thermostat controlled anti-condensation heater is to be provided in the cubicle. Electrical remote control equipment shall also be supplied as specified in the Schedule A - Scope of Work.

The following operating conditions are to apply to the on-load tap changer controls:-

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

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

(C) Operation from the local or remote control switch shall cause one tap movement only, unless the control switch is returned to the off position between successive operations.

(D) It must not be possible for any transformer operating in parallel with one or more transformers in a group to be out of step with the other transformers in the group. Any deviation in the position of tap changers has to stop further function of the AVR. (Out of step protection)

(E) All electrical control switches and local manual operating gear shall be clearly labeled in an approved manner to indicate the direction of tap changing, i.e. raise and lower tap number.

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

iv) Indications

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

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

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

(C) To give indication at the remote control point and at the supervisory control point that a tap change is in progress; this indication to continue until the tap change is completed.

(D) To give indication at the remote control point and at the supervisory control point when the transformers operating in parallel are operating out of step.

(E) To indicate at the tap change mechanism the number of operations completed by the equipment.

4.7.3 Automatic Voltage Control

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

In addition to the methods of control covered by Clause 4.7.2, the following methods shall also be provided.

(A) Automatic Independent - It shall be possible to select automatic independent control for each transformer irrespective of the method of control selected for any other of the associated transformers.

(B) Automatic parallel - It shall be possible to select any transformer for master or follower control.

It must not be possible to operate any tap changer by supervisory, remote or local electrical hand control while the equipment is switched for automatic operation.

4.7.4 Voltage Regulating Relays

Automatic voltage control shall be initiated by a voltage regulating relay of an approved type and suitable for flush mounting. The relay shall operate from the nominal reference voltage stated in the Schedule of Requirements derived from a circuit mounted LV voltage transformer having Class 1.0 or 0.5 accuracy to IEC 60186 and the relay voltage reference balance point shall be adjustable.

The relay bandwidth shall preferably be adjustable to any value between 1.5 times and 2.5 times the transformer tap step percentage, the nominal setting being twice the transformer tap step percentage.

The relay shall be insensitive to frequency variation between the limits of 47Hz and 51Hz. The relay shall be complete with a time delay element adjustable between 10 and 120 seconds. The relay shall also incorporate an under voltage blocking facility which renders the control inoperative if the reference voltage falls below 80 percent of the nominal value with automatic restoration of control when the reference voltage rises to 85 percent of nominal value.

On each transformer the voltage transformer supply to the voltage regulating relay shall be monitored for partial or complete failure. The specified indicating lamp and alarm will be inoperative when the circuit- breaker controlling the lower voltage side of the transformer is open and also that when the tap changer is on control other than automatic control.

The AVR relay shall be fully integrated into the substation automation system and all AVR related operations shall be securely performed from the Substation Automation System. The Substation Automation supplier shall be responsible for integrating the AVR relay.

4.7.5 Remote Control Panels

The remote control panels specified in the Schedule A of Requirements shall be floor mounted sheet steel cubicles of approved type, layout and colour to Munsell 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 transformer and remote control panels as shown on the Specification drawings.

4.7.6 Off-Load Tap Changers

The off-circuit tappings for Auxiliary transformer shall be provided on the higher voltage windings for variation of no-load primary voltage as specified in the Schedule of Requirements.

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 which positively locates the switch correctly at each tapping position. This bolt must be lockable at each tapping position and shall be provided with a suitable padlock and keys. Moving the switch from one tapping position to another shall require that the bolt be withdrawn by hand from its locating socket on the transformer tank against the spring pressure.

Tap-position numbers corresponding to the tapping switch bolt-locating sockets shall be cast or engraved in a metal indication plate fixed to the tank and a keyed metal pointer on the tapping switch operating handle shall show clearly at which tapping number the transformer is operating.

All tap-position indicators shall be marked with one integer for each tap position, beginning at number 1. Adjacent taps shall be numbered consecutively in such a manner that when moving a tap to a new tapping position which has a higher number, the no-load output voltage of the untapped winding increases.

4.8 SUPERVISORY CONTROL

4.8.1 Requirements

Transformer tap change control will be effected from the substation control room with facilities for remote control from the Load Dispatch Centre. All necessary connections, indications, auxiliary switches, relays and changeover switches to meet supervisory control requirements shall be provided and connected under this Contract to terminal blocks in the remote control panels. The supply and installation of the multicore control cables between the remote control panels and the Plant/Telecontrol Interface Cubicle shall be provided under the Contract.

The following supervisory facilities are required:

Controls:

i) Supervisory selection of auto/non auto voltage control.
ii) Tap change raise/lower by direct operation of tap changer.
iii) Tap change blocking on/off.
iv) Remote/Supervisory selection "Override".
v) Parallel/Independent control.

Indications and Alarms:

i) Tap position indication
ii) Tap change out of step alarm
iii) Buchholz and winding temperature non-trip alarm
iv) Tap change control on Local/Supervisory
v) Parallel/Independent, master/follower
vi) Tap change blocking on/off
vii) Tap change control on Automatic/Manual

All contacts for supervisory alarms and indications shall be potential free.

4.9 TERMINAL BUSHINGS AND CONNECTIONS

4.9.1 Bushings

Where stated in the Schedule of Requirements, transformers are to be provided with outdoor type porcelain bushing insulators.

All bushings shall comply with IEC 60137 and the minimum creepage distance for outdoor bushings shall not be less than 25mm per kV of rated voltage between phases.

Outdoor bushing insulators shall be provided with adjustable arcing horns and for rated voltages of 36kV and lower these shall be of the duplex gap type.

Bushings shall be of sealed construction suitable for service under the very humid conditions at

Site and, addition, for the very rapid cooling of equipment exposed to direct sunlight when this is followed by sudden heavy rainstorms.

Typical sections of bushing insulators showing the internal construction, method of securing the top cap and methods of sealing shall be included in the Bid.

The 230kV and 132kV outdoor immersed bushings shall be oil impregnated paper insulated condenser type and have no communication with the oil in the transformer. An oil gauge shall be provided to indicate that the correct level is maintained. 33kV bushings shall be oil filled or solid type.

Completely immersed bushings and lower voltage outdoor immersed bushings may be of other type of construction, subject to the approval of the Engineer but bushings of resin bonded paper construction are not permitted.

On all condenser bushings a tapping shall be brought out to a separate terminal for testing purposes on Site.

Special precautions shall be taken to exclude moisture from paper insulation during manufacture, assembly, transport and erection.

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 interposed 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 chemical 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 imprinted before firing, not impressed.

When a batch of insulators bearing a certain identification mark has been rejected, no further insulators 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 Deleted

4.9.5 Tertiary and Neutral Terminations

Terminations of delta connected tertiary windings and neutral ends of windings shall be as follows;

a) Delta Connected Tertiary Windings

Delta connected tertiary windings for local AC distribution shall be terminated as open air terminal bushings.

Where current transformers are specified in the Schedule of Requirements or on the Drawings, these shall be included on this Contract.

b) Neutral Ends of Windings

Neutral ends of the three phase windings shall be connected at a point accessible from a handhole at the transformer tank top cover. Where current transformers are specified at the neutral ends before the neutral connection of the windings, to be used in conjunction with a protection, they shall be installed such that access is possible through the same handhole and maintenance of these CT, if need be, can be carried out without lowering the transformer oil below the core and winding.

The star connection shall then be brought out via one outdoor bushing insulator capable of withstanding an AC power frequency test.

4.9.6 Mounting of Bushings

Bushing insulators shall be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Neutral bushings shall be mounted in a position from which a connection can be taken to a neutral current transformer mounted on a bracket secured to the transformer tank.

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

A flexible pull-through lead suitably sweated to the end of the winding copper shall be provided for the bushings and is to be continuous to the connector which is housed in the helmet of the bushings.

When bushings with an under-oil end of a re-entrant type are used the associated flexible pull-through lead is to be fitted with a suitably designed gas bubble deflector.

The bushing flanges must not be of re-entrant shape which may trap air.

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

4.9.7 Bushing Current Transformer (BCT)

BCT particulars are stated in the Schedule A of Requirements.

4.10 AUXILIARY POWER AND CONTROL CABLES

4.10.1 Scope of Supply

This Contract includes the supply, installation and termination of the necessary auxiliary power and control cables within items of plant supplied under the Contract.

The 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 utilize compression glands of type E1 to BS.6121 or otherwise designed to secure armour wires and bond them to earthed metal and to provide seals between sheath and gland and between inner sheath and threaded fixing component.

The Contractor shall supply and fit the compression gland and make off individual cores on to the terminal boards, including the supply and fitting of numbered markers on each core.

4.11 TEMPERATURE AND ALARM DEVICES

4.11.1 Temperature Indicating Devices and Alarms

The transformers shall be provided with approved devices of Kilhstrom or equivalent for indicating the top oil temperature and hottest spot winding temperatures. The devices shall have a dial type indicator and, in addition, a pointer to register the highest temperature reached. Each winding temperature device shall have three separate contacts fitted, one of which shall be used to control the cooling plant motors, one to give an alarm and one to trip the associated circuit-breakers.

To simulate indication of the hottest spot temperature of the winding the device shall comprise a current transformer associated with one phase only and a heating device designed to operate continuously at 130 percent of transformer CMR current and for 30 minutes at 150 percent of CMR current, associated with a sensing bulb installed in an oil tight pocket in the transformer top oil.

The winding temperature indicators (WTI) shall be housed in the marshalling cubicle. The tripping contacts of the winding temperature indicators shall be adjustable to close between 80^{o}C and 150^{o}C and to re-open when the temperature has fallen by not more than 10^{o}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^{o}C and 100^{o}C and to re-open when the temperature has fallen by a desired amount between 10^{o}C and 15^{o}C.

All contacts shall be adjustable to a scale and must be accessible on removal of the relay cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 volts and 250 volts AC or DC and of making 500 VA between the limits of 110 and 250V DC. Cooler motor control contacts shall be suitable for operating the cooler contactors direct or, if necessary, through an interposing relay.

The temperature indicators in the marshalling kiosk shall be so designed that it is possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.

The working parts of the instrument shall be made visible by the provision of cut-away dials and glass-fronted covers and all setting and error adjustment devices shall be easily accessible.

Connections shall be brought from the device to terminal boards placed inside the marshalling cubicle.

Terminals, links and a 63mm moving iron ammeter shall be provided in the marshalling kiosk for each WTI for:-

(A) Checking the output of the current transformer.

(B) Testing the current transformer and thermal image characteristics.

(C) Disconnecting the bulb heaters from the current transformer secondary circuit to enable the instrument to be used as an oil temperature indicator. Links shall be provided as shown on the drawing enclosed with this Specification.

4.11.2 Gas and Oil-Actuated Relays

Each transformer shall be fitted with gas and oil-actuated relay equipment having alarm contacts which close on collection of gas or low oil level, and tripping contacts which close following oil surge conditions.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

Each relay shall be fitted with a calibrated glass window for indication of gas volume.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1400mm above ground level, where it shall be terminated by a cock which shall have provision for locking to prevent unauthorised operation.

The design of the relay mounting arrangements, the associated pipework and the cooling plant shall be such that maloperation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps, whether by manual or automatic control under all operating temperatures.

The pipework shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipework shall be avoided.

For two conservators piped separately to the transformer, one Gas and Oil actuated relay shall be installed in the main tank and an Oil-flow relay shall be installed in the OLTC conservator.

4.12 SHIPMENT AND DRYING OUT

4.12.1 Shipment

Each transformer, when prepared for shipment, shall be fitted with a shock indicator or recorder which shall remain in situ until the transformer is delivered to site. In the event that the transformer is found to have been subjected to excessive shock in transit, such examination as is necessary shall be made in the presence of the Engineer.

Where practicable, transformers shall be shipped with oil filling to cover core and windings but, when shipped under pressure of gas, shall be fitted for the duration of delivery to site and for such time thereafter as is necessary, with a gauge and gas cylinder adequate to maintain internal pressure above atmospheric.

4.12.2 Drying Out

All transformers shall be dried out by an approved method at the manufacturer's works and so arranged that they might be put into service without further drying out on Site.

Clear instructions shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barriers or tank cover) which must be taken before the specified vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand the treatment shall be provided with each transformer.

4.13 TRANSFORMER OIL AND TREATMENT

4.13.1 Transformer Oil

The Contractor 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 60kV at 2.5mm electrode gap. The transformer oil shall be new, inhibited, naphthenic based mineral oil, free from additives. It shall be acid-refined and pre-treated and shall have properties complying with IEC 60296-class II.

4.13.2 Oil Purifier Equipment

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

(A) Oil treatment rate not less than 6000 litres per hour.

(B) Water extraction capability down to 5 ppm.

(C) Reduction of dissolved gas content to 1% by volume or less.

(D) Filtration level less than 1 micron.

(E) Oil transfer, vacuum pumps and heaters suitable for 40OV, 3 phase 50Hz, 4 wire, supply.

(F) Vacuum capability approximately 1 Torr.

(G) Facility to apply vacuum to transformer tank during oil filling.

(H) Two 15m lengths of wire reinforced hose coloured differently for clean and dirty oil.

(I) Facility for "closed loop" operation.

(J) 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 envisaged 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.
- Hand hole.
- Silica gel breather.

4.13.4 Collapsible Oil Containers

This section covers the design, manufacture and supply of 9000 litre and 18000 litre capacity two collapsible oil container suitable for on-site storing, transferring and transporting transformer oil associated with the transformers being supplied under the Contract.

Each container shall be made up of one or several layers (and securely bonded together) of tough polymer and textile material which can be folded with ease for transportation purposes. The outer surface of the container shall be coated with a tough abrasion resistant compound and on the inner face with a polymer compatible with the transformer oil.

The containers shall be provided with the following fittings:-

(A) Controllable inlet and outlet valves constructed from brass or aluminium alloy and a gun metal outlet plug.

(B) Air vent plug(s) for air release during oil filling and located at the centre and top of each container.

(C) Two sets of special tools, gauges and spanners necessary to operate and maintain the valves, plugs etc.

The guarantee period is 36 months from the date certified in the Final Acceptance Certificate.

The following details are to be submitted with the proposal to supply the oil container.

i) Descriptive literature and technical specification of the container design.

ii) Manufacturer's production capability and supply record for at least 5 years service experience.

iii) Test certification record.

iv) Type reference number, capacity, weight and dimensions (laid flat unfilled and maximum filled height).

4.14 EARTHING/AUXILIARY TRANSFORMERS

4.14.1 General

Earthing transformers shall comply with IEC 60076-6 and shall be of the oil immersed ONAN type suitable for outdoor installation. They are to have a main interconnected 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 33/0.415 kV. The star-connected secondary windings shall be arranged to give a three-phase, four wire supply with the star point solidly earthed. The secondary winding shall have a continuous rating as stated in the Schedule of Requirements and shall conform to IEC 60076.

4.14.2 Electrical and Short Circuit Characteristics

Earthing transformers will normally have their neutral points connected to earth via a resistance which limits earth fault current to the full load current at the associated power transformer. However, provision is made for solidly earthing the neutral points and, under this condition, the earthing transformers shall be capable of withstanding, both thermally and mechanically without damage, for a period of 5 seconds the application of normal three phase line voltage to the terminals of the interconnected star winding with one line terminal earthed. The current density of the winding under this condition shall not exceed 50A/mm^2.

In addition, the interconnected star winding of each earthing transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for 10 seconds without injurious heating an earth fault current in the neutral connection as specified. The current density under such conditions shall not exceed 23A/mm^2.

4.14.3 Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

(A) Conservator vessel with removable end cover and prismatic oil gauge.
(B) Buchholz relay.
(C) One thermometer pocket with captive screw cap.
(D) Silica gel breather of the oil seal type.
(E) Pressure relief device.
(F) Filter valve and combined filter and drain valves.
(G) Oil sampling device.
(H) Rating plate.
(1) Tank earth terminals.
(J) Lifting lugs.

4.14.4 Secondary Windings

The three-phase, four-wire secondary windings shall be terminated at a three-pole MCCB unit with bolted neutral link and gland entry for a four-core solid dielectric cable. This shall be accommodated in a lockable, fully weatherproof compartment together with a neutral earthing link. The purpose of the neutral earthing link is to connect the 400 V system neutral to earth. It shall be connected between the transformer winding end and a suitably located earthing terminal to which the system earth can be connected.

The windings shall be fitted with off-load tap changer to vary the voltage ±5 percent of the nominal open circuit value in 2.5 percent steps.

4.14.5 Terminal Connections

The 33 kV side of the earthing transformers shall be fitted with oil/air terminal bushings. The earth point connection to the neutral earthing resistor shall be via a 33 kV conductor.

4.15 INSPECTION AND TESTING

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

4.16 FIRE PROTECTION SYSTEM

4.16.1 General

This Sub-clause covers the design and performance requirements of :

Nitrogen Gas Injection Fire Fighting (SERGI type) for the transformer 230/138/34.5kV,225/300MVA, ONAN/ONAF.

It is not intended to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Employer. The system design shall also conform to TAC/ NFPA norms.

The system offered shall comply with the relevant International Standards, conforming to any other approved international standards shall meet the requirements called for in the latest revision of relevant International Standard.

Ambient temperature for design of all equipment shall be considered as 45°C.

The system shall be reliable without making any mal operation. Even if undesirable nitrogen gas injection is made into the transformer tank under normal transformer condition without the internal faults, restoration of transformer by vacuum oil purification up to re-energizing shall complete as soon as possible after the undesired gas injection.

In case of an event of the control power failure, the system shall be able to be operated manually.

Various equipment to perform the required fire protection shall be provided under this Contract.

Reference of standards is listed below. Relevant International Standards other than BS standards shall be subject to approval by the Employer:

BS Standards

BS 381 C	Colours for Identification, Coding & Special Purpose
BS 7629-1	Specification for 300/500 V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire.
BS 8434-1	Methods of test for assessment for power integrity of electric cables
BS 5839-1	Code of practice system design, installation, commissioning and maintenance for fire detection and fire alarm system

BS EN50267-2-1 Common Test Methods for Cables Under Fire Conditions

4.16.2 Nitrogen Fire Fighting

(1) Nitrogen Fire Fighting

The 230/138kV/33kV transformers shall be provided with Nitrogen Injection Fire Protection System (NIFPS). The detail description of fire protection system is given below. Accordingly the Contractor has to make necessary provisions in consultation with supplier of NIFPS for satisfactory operation without affecting the overall performance of transformer.

Oil filled transformer / reactor shall be provided with a dedicated Nitrogen Injection Fire Protection System (NIFPS) for the ratings, mentioned in SLD which shall use nitrogen as fire quenching medium. The fire protective system shall prevent transformer/Reactor oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fires, fire from surrounding equipment etc, it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water and / or carbon dioxide. Fire shall be extinguished within 3 minutes (maximum) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection. The fire protection system shall have been in successful operation in for at least last three years for protection of transformers of 230/138/33 kV and higher voltage class. The list of past supplies in local market along with performance certificate from users of the system shall be submitted for approval.

(2) Activation of the fire protective system

Mal-functioning of fire prevention/ extinguishing system could lead to interruption in power supply. The bidder shall ensure that the probability of chances of malfunctioning of the fire protective system is practically zero. To achieve this objective, the bidder shall plan out his scheme of activating signals which should not be too complicated to make the fire protective system inoperative in case of actual need. The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button control at Control box and local manual control in the fire extinguishing cubicle shall also be provided. The following electrical-signals shall be required for activating the fire protective system under prevention mode / fire extinguishing mode.

(3) Auto Mode

(a) For prevention of fire:

Differential relay operation

Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)

Tripping of all circuit breakers (on HV &LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system

(b) For extinguishing fire

Fire detector

Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)

- Tripping of all circuit breakers (on HV &LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system.

(4) Manual Mode (Local / Remote)

Tripping of all circuit breakers (on HV &LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system

(5) Manual Mode (Mechanical)

The system shall be designed to be operated manually in case of failure of power supply to fire protection system

(6) Description

Nitrogen injection fire protection system should be a dedicated system for each oil immersed transformer / reactor. It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the fire wall (if fire fighting wall exists). The FEC shall be connected to the top of transformer/reactor oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer/reactor tank) from its bottom through oil pipes. The fire extinguishing cubicle should house a pressurized nitrogen cylinder(s) which is connected to the transformer oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to fire extinguishing cubicle and from TCIV to signal box. Fire detectors placed on the top of transformer/reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

(7) Operation

On receipt of all activating signals, the system shall drain pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

(8) System components

Nitrogen injection fire protection system shall broadly consist of the following components. However, all other components which are necessary for fast reliable and effective working of the fire protective system shall deemed to be included in the scope of supply.

(a) Fire Extinguishing Cubicle (FEC)

The FEC shall be made of CRCA sheet of 3 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade to be in line with BS: 381 C : 1988 – Colors for Identification, Coding and Special Purposes). It shall have hugged split doors fitted with high quality tamper proof lock. The degree of protection shall be IP55. The following items shall be provided in the FEC.

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas
- Pressure monitoring switch for back-up protection for nitrogen release
- Limit switches for monitoring of the system

- Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer/reactors

- Panel lighting (CFL Type)

- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

- Space heater

- Others if necessary

(b) Control box

Control box is to be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

- System on
- TCIV open
- Oil drain valve closed
- Gas inlet valve closed
- TCIV closed*
- Fire detector trip *
- Buchholz relay trip
- Oil drain valve open*
- Extinction in progress *
- Cylinder pressure low *
- Differential relay trip
- PRV / RPRR trip
- Transformer/reactor trip
- System out of service *
- Fault in cable connecting fault fire detector
- Fault in cable connecting differential relay
- Fault in cable connecting Buchholz relay
- Fault in cable connecting PRV / RPRR
- Fault in cable connecting transformer /reactor trip
- Fault in cable connecting TCIV
- Auto/ Manual / Off
- Extinction release on / off
- Lamp test

- Visual/ Audio alarm*
- Visual/ Audio alarm for DC supply fail *
- Space heater
- Others if necessary

*** Suitable provision shall be made in the control box, for monitoring of the system from remote substation using the substation automation system.**

(c) Transformer Conservator Isolation Valve

Transformer conservator isolation valve (TCIV) to be fitted in the conservator pipe line, between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator.

(d) Fire Detectors

The system shall be complete with adequate number of fire detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

(e) Signal Box

It shall be mounted away from transformer / reactor main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & fire detectors and for further connection to the control box. The degree of protection shall be IP55

(f) Cables

Fire survival cables (capable to withstand 750° C.) of 4 core x 1.5 sq. mm size for connection of fire detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1, BS 8434-1 and BS 5839-1, BS EN 50267-2-1 or relevant International standards.

Fire Retardant Low Smoke (FRLS) cable of 12 core x 1.5 sq. mm size shall be used for connection of signal box / marshalling box near transformer/reactor and FEC mounted near transformer/reactor with control box mounted in control room.

Fire Retardant Low Smoke (FRLS) cable of 4 core x 1.5 sq. mm size shall be used for connection between control box to DC and AC supply source, fire extinguishing cubicle to AC supply source, signal box/ marshalling box to transformer conservator isolation valve connection on transformer/reactor.

(g) Pipes

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

(9) Other items

(a) Oil drain and nitrogen injection openings with gate valves on transformer / reactor tank at suitable locations.

(b) Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing TCIV.

(c) Fire detector brackets on transformer / reactor tank top cover.

(d) Spare potential free contacts for activating the system i.e. in differential relay, Buchholz relay, Pressure Relief Device / RPRR, Circuit Breaker of transformer/reactor

(e) Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.

(f) Cabling for fire detectors mounted on transformer /reactor top cover

(g) Inter cabling between signal box, control box and Fire Extinguishing Cubicle (FEC).

(h) Butterfly valves /Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.

(i) Supports, signal box etc. which are to be painted with enameled paint.

(10) Technical Particulars

Fire extinction period from commencement of nitrogen injection	: 30 s. (max.)
Total duration from activation of fire protection system to complete cooling	: 30 minutes (Max.)
Fire detectors' heat sensing temperature	: 141°.C
Heat sensing area per detector	: Up to a radius of 800 mm
Transformer Conservator Isolation valve setting	: 60 liter/ min (minimum)mm
Capacity of nitrogen cylinder	: 68 liter (maximum) water capacity and shall hold 10 m^3 (minimum) gas at pressure of 150 kg/cm^2
Power Supply	
For control box	: 110 V DC

For fire extinguishing cubicle for lighting	: 240 V AC

(11) Mandatory Spare Parts

Cylinder filled with Nitrogen of required capacity per substation	: 1 No.
Fire detectors per transformer	: 3 Nos.
Regulator assembly per substation	: 1 No.

(12) Tests

Reports of all type test conducted as per relevant IEC standards in respect of various bought out items including test reports for degree of protection for FEC / control box / signal box shall be submitted for approval.

The supplier shall demonstrate the functional test associated with the following:

- Fire Extinguishing Cubicle, Control Box.
- Fire Detector.
- Transformer Conservator Isolation Valve

The performance test of the complete system shall be carried out after erection of the system with transformer at site. Detailed layout drawings, equipment drawing along with 4 sets of Operation and maintenance manual along with soft copies (in CDs) shall be submitted by the Contractor along with the consignment.

4.16.3 Fire Wall

The fire wall having suitable height shall be installed between transformers to prevent the health transformer from the spread fire. The wall shall be constructed by the reinforced concrete.

SECTION 5

PROTECTION, METERING AND CONTROL

TABLE OF CLAUSES

SECTION 5

PROTECTION, METERING AND CONTROL

5.1 GENERAL

The protection and control facilities shall be suitable for the power system arrangement as shown in the Drawings of this Technical Specifications.

For standardization of operation performance, facilities and spare requirements, the protection relays, control & automation systems including complete panel to be supplied under this project shall comprise GE (France/UK), ABB (Switzerland/Sweden), Siemens (Germany), SEL (USA/UK/Canada) make manufacture.

The protection shall be sufficiently sensitive to cater for the minimum fault level condition. This will be advised later. The protection shall also be suitable for a system fault level equal to the switchgear rating as specified in clause 1.2.1 of section-1 of this volume (2 of 3). All current transformer design shall be based on these fault levels.

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

5.2 FAULT CLEARANCE TIMES

230 kV, 132 kV and 33 kV systems overall fault clearance times (i.e. from fault initiation to arc extinction) shall not exceed the following:

Type of Fault		Maximum Fault Clearance Time		
Nominal system voltage between phases	kV	230	132	33
Substation and Transformer fault	msec	100	120	160
Line fault				
(a) Up to 72% of the line length (ie. 90% of a distance relay Zone 1 reach setting of 80% of the line impedance)	msec	100	120	160
(b) 72% to 100% of the line length where, (@) plus protection signalling time.	msec	130	150	190

These requirements must be fulfilled under all system conditions including maximum dc current offset and any time delay. Clearance within these times shall be achieved for all types of faults except high resistance earth faults detected by DEF protection or under circuit breaker failure conditions.

5.3 ARRANGEMENT OF FACILITIES

Control and relay equipment shall be mounted on panels and cubicles as specified and shall be installed in permanent buildings on the substation sites. The order of the panels shall follow the sequence shown on the drawings.

Control panels shall incorporate all necessary control and indication facilities for the operation of the plant and equipment at the associated substation. In addition, the plant may be remotely controlled and supervised from the National Load Dispatch Centre (NLDC) in Dhaka.

The Gateway system for communication to the NLDC shall be supplied under this contract including all necessary items like auxiliary switches, relays and changeover switches, etc. Where specified for the mounting of, and connection to, interposing relays and transducers, links shall be provided to enable transducers to be isolated for test purpose and shortening facilities shall be provided where transducers are used in the secondary of the current transformers. All circuits provided under this contract whether or not they are subject to the system control requirements at the present time, shall be designed and constructed so that the standard facilities specified can be readily provided as required in the future.

The contractor shall be responsible for ensuring the correct operation of the protective equipment and shall submit for approval recommended relay settings supported by design calculations for all protective equipment been supplied. The Employer reserves the right to ask the Contractor to get the design calculations approved by the manufacturer of the Protection equipment and or get the confirmation for the suitability of the particular protective relay for the proposed application. In case the proposed Protective relay is not suitable for the proposed application the Contractor shall change to a suitable relay as recommended by the manufacturer without any cost implications to the Employer.

5.4 MULTICORE CABLE DIAGRAMS

This Contract includes the preparation of cabling schematic diagrams, showing the approved routing of cores in the various cables, and detailed cable schedules and connection diagrams for all the cables associated with each item of equipment.

5.5 TEST AND EARTHING FACILITIES

Each control or relay panels shall be provided with a copper earth bar of not less than 150 sq. mm Cross-section and arranged so that the bars of adjacent panels can be joined together to form a common bus.

The common earthing busbar of control and relay panels shall be connected to the main station earthing system via a copper earthing connection of not less than 150 sq. mm.

Software for testing the protection & control devices shall be included in the scope of supply. In addition, for secondary injection testing of the protection & control devices, provision shall be made in the panel for current & voltage injection using standard test set and disconnecting type terminal blocks with facility for short circuiting of current transformer secondary circuit etc. by means of movement of links from their normal operating position, or any other testing arrangement approved by the Employer.

5.6 PROTECTION DEVICES

Simplified arrangements of the main connections and protection for the various items of plant are shown in the Drawings of this Technical Specifications.

Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits. All equipment are to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

Current transformers, where possible, are to be located so as to include the associated circuit breaker within the protected zone and shall be located generally as indicated on the schematic drawings included in this Specification.

Transformer Buchholz, winding temperature and tap changer protective devices are to be supplied under this contract, and all necessary interposing relays, tripping relays and cabling associated with these devices shall be supplied and mounted under this Contract.

5.7 RELAYS

5.7.1 General

Relays shall conform to IEC 61850 standards, be of approved types complying with IEC 60255 or BS 142 and 5992, parts 1, 2 and 3 as appropriate, fully tropicalized, and shall have approved characteristics. Relays designed identical to relays with a minimum of five years proven field experience will only be accepted. Supply record of proposed relays shall be furnished for the last five years. The Employer will reject any design he considers unsatisfactory or having insufficient field experience. All the Protective relays shall be numerical type. Numerical relays shall be configured in such a way that at least two(2) nos relays shall be provided for each feeder.

The protection relays, shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases and of the draw out type with rear connections. The panel front side shall be covered by a transparent glass door.

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.

Electrically reset tripping relays shall be provided where necessitated by the system of control, such as for those circuits subject to remote supervisory control.

Relay contacts shall be suitable for making and breaking the maximum currents which they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved auxiliary contacts, relays or auxiliary switches shall be provided. In such cases the number of auxiliary contacts or tripping relays operating in tandem shall be kept to the minimum in order to achieve fast fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate, shall be provided with LCD, LED or flag indicators, phase coloured where applicable. LCD, LED or Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element.

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 provided.

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 utilize 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 internal 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 minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energized from the positive pole of the battery.

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

Numerical protection shall be designed in such a way that in case of a failure of DC auxiliary infeed, the full information need 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 utilize a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation.

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 are suitable for the intended applications.

5.7.2 Electromagnetic Compatibility

In certain cases, eg. distance protection, current differential etc., electronic relays, or devices utilizing microprocessors are specified and electromagnetic devices will not be accepted.

Where such devices are required, they and the ancillary circuits connected to them, such as power supplies, current and voltage transformer secondaries, status, tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an EHV substation.

Adequate steps, by means of suitable design, shall be taken to prevent Electromagnetic Interference (EMI) (generated by sources such as circuit breakers, disconnecters, lightning, radio or radar emissions, switching contactors in dc circuits, etc.) or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.

All relays offered must therefore have been type tested to meet the current requirements of IEC 60255 with respect to High Frequency disturbance, Fast Transients, Electrostatic Discharge, Radio Frequency Interference testing, etc.

5.8 OVER HEAD LINE PROTECTION

5.8.1 General

The adopted transmission line protection schemes as per voltage levels are as follows:

i) 230kV

Main-1 Scheme		Main-2 Scheme		Reclosing	Details
Relaying	Comm. Ch	Relaying	Comm. Ch		
Differential (87L) Distance (21) Transfer Trip (PUTT/POTT)	Optical	Distance (21) Transfer Trip (PUTT/POTT)	Optical	3ph/1ph	Full scope of Distance and multiple OC function
67/67N, 50/51, 50N/51N		67/67N, 50/51, 50N/51N			

In case of including underground cable, which is more than 10% of total length, reclosing system shall not be adopted.

ii) 132kV

Main Scheme		Back up Scheme	Reclosing	Details
Relaying	Comm. Ch			
Differential (87L) Distance (21) Transfer Trip (PUTT/POTT)	Optical	67/67N, 50/51, 50N/51N	3ph/1ph	Full scope of Distance and multiple OC function

In case of including underground cable, which is more than 10% of total length, reclosing system shall not be adopted.

The overhead transmission lines shall be protected by PUTT/POTT scheme with full scheme Distance relay and multiple OC relay as a back up relay. And the protection shall be compatible with remote end's protection system.

The differential relays shall be Numerical type Current Differential Relay and shall be suitable for operation through optical fibers. Optical Ground Wire (OPGW)/OPC (Optical Fiber Cable) shall be installed in the overhead lines and terminated at the substation gantry by the transmission line Contractor. From substation gantry to control room separate under ground optical fiber cable are to be installed and terminated under this contract. A dependable communication facility is needed to allow information exchanges between relays at different line end so that each can compare the local currents with the currents at the remote ends via optical fiber link.

Three pole tripping facilities shall be provided.

The permissive inter-trip facility shall be provided for inter-trip circuit breakers at the remote ends. The relay shall have facilities for independently tripping duplicated circuit-breaker's tripping coils.

Only the backup protection can be incorporated in the bay control unit and not the main 1 and main 2 protection. Main protections shall be provided separately.

Each set of protection will be energised from separate current transformers and shall have facilities for independently tripping duplicated circuit-breaker tripping coils and initiating auto-reclosing, breaker failure protection, inter-tripping, alarms, fault location equipment, disturbance recorders etc. The Contractor shall ensure that the relay contacts used for initiation of auto reclosing shall have the same dwell time as the main tripping contacts to avoid any problems arising from contact racing with the auto reclose relay.

Two sets of protection shall consist of different types of relays either from the same manufacturer or from different manufacturers. Separate elements shall be provided for phase and earth fault measurement. Separate elements shall also be provided for each zone. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of fault and to allow for variation in the path of earth faults on the system.

5.8.1.1 Distance as Main-1 & Main-2 Protection and Directional Earth Fault Protection as Backup

The main protection (First and Second main) shall be of numerical type and shall be provided by distance relays for use with a signalling channel.

The relay scheme offered shall be suitable for use in the permissive under-reaching, permissive overreaching, 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 over head 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 tripping 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 'echos' 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.

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 over-reach 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.

Distance protection back-up zones shall also trip the remote end circuit breaker(s) via a direct intertripping 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 characteristics with adaptive reactance measurement to avoid overreach or underreach for resistive faults with pre fault load are preferred for earth faults. The relays shall operate for faults in the direction of the protected line only. Under no circumstances shall they operate for reverse faults even when the voltage supplied to the relay falls to zero on all three phases nor shall they operate due to the transient response of the capacitive voltage transformers following reverse close-up faults. Details of methods used for polarising the relays to deal with faults close to the relaying point shall be provided. Zone 3 shall be capable of being set as either directional or non-directional and shall be capable of being independently off set in both directions.

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 requirements are given in Section 5.11. The distance protection shall be suitable for such a scheme and the Contractor shall substantiate by calculation or other means that phase selective tripping will be achieved under the system conditions anticipated in the daily operation.

The Contractor may request whatever information he requires for carrying out the necessary calculations.

Auto reclosing shall be capable of being blocked for

- i) any three phase fault
- ii) any Zone 2 or Zone 3 time delayed trip
- iii) carrier channel out of service
- iv) DEF aided trip
- v) DEF back up time delayed trip
- vi) 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 autoreclose 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 current.

Under no circumstances shall any line protection operate because of normal system switching including 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 msecs 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 distance protection. In the event of loss of one, two or three phases, the monitoring system shall inhibit relay operation and initiate an alarm. The VT supervision unit associated with the distance relay shall also inhibit the DEF protection in the event of VT fuse failure.

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 cater for high resistance faults which cannot be detected by the distance protection. The same teleprotection signalling channel shall be used for the directional earth fault scheme and the distance protection scheme. An echo feature shall be included with the DEF Scheme and shall be subject to approval by the Engineer.

The directional relays shall be dual polarised i.e. polarised with zero sequence voltage and current. The relay sensitivity shall be adjustable between approximately 5 and 10% of rated current. A relay characteristic angle of 60 degrees is preferred but alternative angles will be considered. It is appreciated that because the 230kV 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 following 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 also 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 blocking 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 relays shall be design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Distance to fault indication, diagnostics, etc and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Man Machine Communication (MMC) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection. A separate communication port shall be provided so that the distance relays can in future communicate with the Station monitoring system as well as easily be integrated into Station Control Systems. A PC with a Man Machine Communication (MMC) software for setting of the relay shall be included in the scope of supply.

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.

5.8.1.2 Differential as Main-1 & Main-2 protection and Directional Earth Fault Protection as Backup

The protection shall be of numerical type line differential relay and shall be suitable for short underground or over head line protection (single or double circuit) in solidly or low impedance grounded systems.

The relay shall incorporate a facility to compensate for different CT ratios at each line terminal.

A tripping signal for a fault shall be given within 30 ms of fault occurrence (including main tripping relay).

The differential protection shall measure the currents of three phases independently and the tripping shall take place should the comparison of the values in both the terminal stations result in a differential current above a set level. The relay shall incorporate methods for ensuring protection stability for external faults with allowance for CT transformation errors. The minimum CT requirements for the protection must be clearly stated.

The protection shall offer phase-selective tripping, if required.

For digital communication between relays at each line terminal, the protection shall be suitable for direct interfacing to the available communication link according to the particular application. This may be a pair dedicated optical fibres, or a digital interface card of a multiplexed communications link. Where the multiplexer forms part of an overall communications system, the relays shall incorporate the necessary algorithms to ensure stability with load current during communications path route-switching.

Upon detection of a communications channel failure and following a time delay of less than 10 seconds, an alarm shall be given. In the event of signalling channel failure the protection must not trip due to load or emergency load currents.

The protection system shall incorporate at least one zone of directional under impedance protection, to provide time-delayed remote back-up tripping in the even of a fault in an adjacent remote circuit not being cleared by its main protection. This protection function shall be blocked in the event of VT signal failure.

The protection system shall offer standby directional protection elements that can automatically or manually (as selected) be brought into service in the event of data communications link failure between the relay terminals. The alternative protection shall, preferably be one zone of high-speed underreaching distance protection and one zone of time-delayed overreaching distance protection.

In addition to the tripping contacts the protection shall provide all necessary contacts for initiating phase-selective auto re-closing, breaker failure protection, disturbance recorder, signalling and alarms.

For overhead lines, the relay shall be compatible with the external single and three phase autoreclose system which is to be common for the Main-1 and Main-2 protection, as detailed in Section 5.11.

The protection system shall include a secure integral inter-tripping facility, which can be used as a secondary inter-tripping path by external breaker fail protection.

The relay shall be equipped with self-supervision of both its software and hardware (including VT signal supervision). Detection of a failure shall result in the affected part(s) of the protection system being blocked, so that no incorrect tripping will occur.

In the event of a relay failure an alarm contact must operate and the nature of the failure should be indicated where possible.

The trip output contacts of the relay must either be suitable for switching the breaker trip coil currents directly, or an interposing trip relay with heavy duty contacts must be provided. In the event of breaker failure, where the circuit breaker auxiliary contact may not interrupt the trip coil current, the trip contacts within the differential relay should not be damaged if the relay resets following breaker fail protection clearance.

5.8.2 Coupling Bay Protection

The Coupler bay shall be provided with overcurrent instantaneous trip relay protection and over current time delay relay protection and instantaneous trip relay protection. Relays shall comply with the requirements of clause 5.7.

In case of main & transfer bus arrangement all trip-signal of line and transformer feeder protection shall be transferred to the coupling breaker in case the feeder breaker is bypassed and the feeder is protected by the coupling-bay circuit breaker. This shall be provided by auxiliary relay, not by auxiliary contacts of the circuit breaker by-pass isolator.

5.9.1 BUSBAR PROTECTION

The busbar protection (double scheme) shall be low impedance type numerical relay The protection shall be extensible to cover the final substation arrangements and Bidders shall state what extra material is required.

The busbar protection shall have the following features:

(a) 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 conditions. They shall meet the fault clearance time of 100ms under all conditions.

(b) 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. Operation of either of these relays shall block closing of the associated circuit breaker.

(c) Each trip relay shall trip the circuit-breaker via both trip coils. Both relays on the 132 kV transformer circuits shall trip the associated circuit-breakers.

(d) The operating time of the measuring relays shall not exceed 30 msecs at five times the relay current setting.

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 ratios.

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 busbar faults will be advised 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, isolating and shorting links, etc. A lockable Busbar protection ON/OFF switch shall be provided.

Current transformer secondary bus wiring should be suitably dimensioned to reduce current transformer 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 5.9.2.

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 type and the bay units shall be fixed as close to the CT’ s 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.

5.9.2 Conditions of Acceptance of Busbar Protection Systems Submitted on the Basis of Calculated Performance

The Engineer is prepared to accept Calculated Performance data for differential busbar protection systems in lieu of heavy current tests, subject to the following:

i) The rated stability limit shall be no less than the three phase symmetrical breaking capacity of the associated switchgear.

ii) The overall fault setting for any type of fault shall be between 10% and 30% of the minimum fault current available. The minimum fault current available for a busbar fault will be advised later.

iii) Current transformer knee point voltages shall not be less than twice the relay circuit setting voltage.

iv) The maximum peak voltage across current transformer secondary wiring shall not exceed 3 kV under maximum internal fault conditions.

v) Associated current transformers shall be 5P20, low reactance type. Split core type current transformers will not be accepted.

vi) The contractor shall submit for the Engineers approval a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burdens between current transformers and relays, details of the relay circuits and performance calculations.

5.10 CIRCUIT BREAKER FAILURE PROTECTION

Breaker failure protection shall be fitted to all 230kV & 132kV circuit breakers. The breaker failure protection on a circuit-breaker shall be initiated by all the other protection devices which normally initiate tripping of that breaker including the receipt of a direct intertripping signal from a remote line end. In the event of the circuit-breaker failing to open within a pre-selected time, the breaker failure protection shall 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 communication link or power line carrier circuits.

The position of each circuit-breaker shall be monitored by a current check relays fed from the protection current transformers as shown on the drawings. The relay outputs shall be connected in series in a "two out of two" arrangement. The relays shall have an operating time of approximately 10 msec. and a consistent reset time of less than 15 msec. The relays shall be capable of remaining in the operated position continuously and of carrying twice the circuit rated current continuously.

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

The operating time from initiation to back tripping output shall be selected by means of duplicated timers with a setting range of 50-500 msecs. The two timers per circuit breaker in the case of the 230 kV scheme shall be connected in series 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 relay/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.

5.11 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 conjunction 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 aided 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 protection 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 programmable.

(a) Single pole, high speed, auto-reclose: Auto-reclosure shall only be initiated in the event of a single phase to earth fault. All other types of faults shall result in three phase tripping without auto-reclosing.

(b) Three pole delayed reclosing: Delaying reclosing shall only be initiated in the event of a single phase or two phase fault. Three phase faults shall result in tripping without auto-reclosing.

(c) Single pole, high speed and/or three 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 without re-closing shall take place for three phase faults.

(d) 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 co-ordinated 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 not, however, be less than five seconds, and the reclaim timer range shall extend to 180 seconds. (The reclaim time commences at the instant the reclose command is given to the circuit-breaker and, therefore, includes the circuit-breaker closing time).

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 number 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 reclosing only when the line is de-energised and the busbar is energised. The line is considered to be de-energised when the voltage is less than twenty percent of rated voltage, and the busbar is considered to be energised when the voltage is greater than eighty percent of rated voltage.

(A signal shall be provided from the dead line check relays for interlocking of the line earth switches to prevent the switches being closed onto a live line).

When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall monitor the magnitudes of the two voltages across the open circuit-breaker, and the phase angle and slip frequency between these voltages. Closing shall only be permitted when these are within prescribed limits.

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

5.12 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 msecs.

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 withstand time of the relay. The contractor shall provide copies of type test reports to show that this requirement 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 characteristic 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 voltage 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.

5.13 TRANSFORMER PROTECTION

5.13.1 Biased Differential Protection

The transformer differential protection shall be fully numerical design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Trip indications, diagnostics, etc and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Human Machine Interface (HMI) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection.

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

Separate facilities shall be provided to enable bias and operating settings to be adjusted. The minimum operating setting shall not be greater than 20 per cent of the rated full load current of the transformer.

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 calculated using the transformer impedance only.

Correction for matching transformer vector groups and main CT ratio's for Transformer Differential protection shall be performed within the relay without the use of external interposing-transformer.

The relays shall have magnetising inrush current restraint of the second harmonic or other approved means. All necessary interposing current transformers shall be provided under the contract.

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

5.13.2 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 impedance 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 circuited.

The Engineer is prepared to accept calculated performance for instantaneous high impedance restricted earth fault protection in lieu of heavy current tests, subject to the conditions in Clause 5.9.2 except:

i) The rated stability limit shall be as specified above.

ii) The fault setting shall be as specified below.

   (a) When the transformer winding is connected to a solidly earthed power system, the fault setting shall be between 10% and 60% of the rated current of the winding. When the transformer winding has more than one rating, the setting shall be based on the lower rating.

   (b) When the protected transformer is not connected to a solidly earthed power system the fault setting shall be between 10% and 25% of the minimum current available for an earth fault at the transformer terminals.

5.13.3 230/132kV 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 shall be arranged to trip the 132kV circuit breaker and stage 2, the 230kV circuit breaker. 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.

5.13.4 Gas Pressure (Buchholz) Protection

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

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

5.13.5 Oil and/or Winding Temperature

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

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

5.13.6 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.

5.13.7 Tap Changer Oil Surge

Transformers will be provided with an oil surge or pressure operated device having contacts for purposes 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.

5.13.8 Standby Earth Fault Protection

Standby earth fault protection shall be provided for all earthing transformers/resistors, fed from a current 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 inverse time relay may be offered.

5.13.9 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 operating 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

230kV and 132 kV circuit breakers are equipped with two trip coils. One tripping relay shall initiate tripping via one trip coil and the other tripping relay via the second trip coil.

5.14 DC AUXILIARY VOLTAGE OPERATING RANGE

DC operated relays, coils, elements, etc. will be operated from a 110 V rated d.c. battery, which under float charging conditions operates at about 125 V d.c. operated relays coils elements etc. shall be suitable for operation over a voltage range of 66 V to 143 V. ie. 110 - 40% + 20%.

5.15 TELEPROTECTION SIGNALLING

Details of protection initiation and various permissive and direct intertripping signals are indicated as follows:

Proposed Fibre Optic Multiplexer equipment system layout Drawing of this Technical Specifications.

5.16 TRIPPING RELAYS

All tripping relays, where specified shall be of the high speed, (less than 10 ms), high burden, heavy duty (greater than 150 W) type suitable for panel mounting.

Relays shall comply with the requirements of Clause 5.13.7.

5.17 PROTECTION SETTINGS

Relay settings with calculation for all unit type protective schemes and shall be submitted to the 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.

5.18 SUBSTATION AUTOMATION SYSTEM

5.18.1 Scope of Supply

This specification covers the design, manufacture, inspection, testing at the manufacturer's works, erection and commissioning of a Substation Automation System, as shown in Drawing of this Technical Specifications & described in the following sections, to control and operate the 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 (SA) shall comprise full station and bay protection as well as control, monitoring and communication functions, and provides all functions required for the safe and reliable operation based on IEC 61850 standards. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package and 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 shall secure control from and information flow to remote network control centres. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer and trip/close coils in the switchgear without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Employer.

The contractor will have option to choose different type of communication network for bay level and process level based on IEC 61850. But 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 IED's for protection and control functions shall maintain high availability and reliability together with bay independence through extensive self-supervision and state-of-the-art technology. All IED's shall be directly connected to the IEC 61850 bus and shall use only IEC 61850 protocol for communication. No proprietary protocols shall be used.

The system shall be capable of having its computing power increased in the future by the addition of additional computing systems.

The system design life shall be not less than 20 years.

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

The SA supplier shall demonstrate that the system proposed has been designed, installed and commissioned in accordance with IEC 61850 standards and shall provide evidence of satisfactory service experience during the past 5 years.

5.18.2 Compliance with standards

For design and type testing of the protection and control equipment, the following standard s shall be applicable:

5.18.2.1 General List of Specifications

- IEC 60255: Electrical Relays
- IEC 60038: IEC Standard voltages
- IEC 68068: Environmental testing
- IEC 60664: Insulation co-ordination for equipment within low-voltage systems
- IEC 61850: Standard for Substation integrated protection and control data communication

5.18.2.2 Detailed List of Specifications

- IEC 255-6: Measuring relays and protection equipment
- IEC 255-7: Test and measurement procedures for electromechanical all-or-nothing relays
- IEC 68-2-3: Test Ca: Damp heat steady state
- IEC 68-2-30: Test Db and guidance: Damp heat, cyclic
- IEC 255-5: Insulation tests for electrical relays
- IEC 255-22: Electrical disturbance tests for measuring relays and protection equipment:
- IEC 255-22-1: 1 MHz burst disturbance test
- IEC 255-22-2: Electrostatic discharge test
- IEC 255-22-3: Radiated electromagnetic field disturbance test
- IEC 255-22-4: Fast transient disturbance test
- IEC 255-11: Interruptions to and alternating component (ripple) in D.C. auxiliary energising quantity to measuring relays
- IEC 255-6: Measuring relays and protection equipment
- IEC 255-21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment
- IEC 255-21-1: Vibration tests (sinusoidal)
- IEC 255-21-2: Shock and bump tests
- IEC 255-21-3: Seismic tests
- IEC 255-0-20: Contact performance of electrical relays
- IEC 870-3/class 2: Digital I/O, Analogue I/O dielectric tests
- IEC 801-5/class 3: Digital I/O Surge withstand test
- IEC 870-3/class2: Radio interference test
- IEC 801-4/4: Transient fast burst test
- IEC 801-2/4: Static discharge
- IEC 801-3/3: Electromagnetic fields

5.18.3 Design and Operating Requirements

5.18.3.1 General

The SA shall be suitable for operation and monitoring of the complete substation including future extensions. The supplier shall provide a high quality SCD file (System Configuration Description file) complete with ICD files (IEC device capability files) and substation topology which will enable easy extension of the substation in future. The offered products shall be suitable for efficient and reliable operation and maintenance support of the substations.

The SA system shall be state-of-the art design suitable for operation in high voltage substation environment, follow the latest engineering practice, ensure long term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

As shown in the SA system structure, protection is an integral part of the SA system and protective relays shall be directly connected to the interbay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote control location.

Failure behaviour of the hardware and software functions shall be addressed and related diagnostic and rectification working instructions shall be provided. The system performance, if failure of communication to NLDC, main and redundant computer base workstations, central functions, data model, control and protection IED's, station and bay level communication shall also be clearly addressed.

5.18.3.2 Modes of Operation

The operator stations and specified remote users shall have following operational modes, each password protected.

Monitoring Ability to select graphic displays and lists for viewing only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.

Control Selection of graphic display and lists. Able to acknowledge station and SA alarms, complete controls, dressing, etc. associate with normal real time of the control of the substation.

SA Engineering Provides all the SA monitoring functions, together with online facilities for program/database/format modifications and checking without the possibility of executing power system controls.

System Manager Provides access to all system functions, including assignment of passwords and system maintenance activities.

In addition a facility to provide access to the numerical Protection relays including AVR, change/modify relay settings & AVR parameters and fault and disturbance data shall be provided.

A series of passwords shall be personally assigned to operators in each of the above categories.

It shall be possible for substation operators to log on either of the substation workstation and to be allocated the appropriate mode of operation relevant to the password. SA System Engineering work and access to the protection relays and fault and disturbance recording information shall generally be carried out at the Engineering workstation or remote master station.

All the workstation and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

Similarly, an operator manual entry applied at a workstation shall be immediately displayed at other workstations where this data is presented.

5.18.3.3 Project Specifications

Specific functions required and boundary conditions of the SA are detailed elsewhere in this specification. The project specific drawings are attached:

- Overall single line diagram
- General system architecture
- Location of substation buildings
- Control and operation principles
- Protection schemes

5.18.3.4 Vendor's Experience and Local Support

Only experienced and technically capable manufacturers with minimum 5 years experience in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred manufactures will be those who have experience in deliveries of the full scope of station automation systems and services. This experience has to be substantiated by means of reference installations being in service under similar environmental conditions for at least 5 years. In order to assess the vendor's experience with similar projects, the vendor is required to submit the following with his bid:

- Technical design specifications and description of SA
- Catalogues and brochures of equipment and devices offered
- Reference list

The vendor shall assure for long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SA equipment (not less than10 years).

5.18.3.5 Quality Assurance and Inspection

Quality Assurance of design and development, production, installation and servicing of material and workmanship shall be governed by ISO 9001. Supporting documents to prove ISO 9001 third party approvals shall be provided with the offer.

The SA system shall be pre-assembled and tested at the vendor's workshop before shipment.

5.18.4 General System Design

The system shall be so designed that personnel without any background in microprocessor based technology can operate the system easily after they have been provided with some basic training.

System control from the substation control room will be with the help of an Industrial Computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

- Acquisition and plausibility check of switchgear status
- Control of switchgear
- Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays
- Display of actual measured values (U, I, P, Q, f)
- Display of events
- Display of alarms
- Display of trends
- Sequence control functions
- Dynamic busbar coloring
- Disturbance records and fault location
- System self-supervision
- Hard copy printing

The offered SA shall support remote control and monitoring from NLDC centre via an industrial grade gateway with redundant CPU as well as redundant DC/DC converters. PC based gateways which contains moving parts will not be accepted. The gateway should be designed for a life of at least 20 years. The gateway shall provide for communication to/from remote control centres via IEC60870-5-101 protocol. Even if the Station PC is not available, it shall be possible to control the station from NLDC centre as well as from the backup control panel in the individual bays with all interlocks. Interlocking in case of emergency (i.e if bay controller fails) should be waived locally by means of a switch with key lock by the maintenance engineer for all the switchgear.

Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimizing maintenance time to repair.

As shown in the system drawing, the SA shall be structured in two levels - station level and bay level. The data exchange between the electronic devices on both levels shall take place via an inter-bay bus as per IEC 61850 standards. The entire station shall be controlled and supervised from the station level PC. It shall also be possible to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay should fail. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz., NLDC, station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level.

Each bay control and protection unit shall be independent of each other and its functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station.

The SA shall 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 SA system 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 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 de-centralized concept with bay oriented distributed intelligence for safety and availability reasons. Functions shall be decentralized, object oriented and located as close as possible to the process.

The substation monitoring/protection system shall supply data for maintenance, repair and remote parameter 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 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 the access to SMS with different access levels. The required SMS software and application specific firmware (for relay parameterisation) shall be provided with associated tools and equipment. The required engineering tools analysing software also shall be provided/installed both in the station PC and the remote Master Analysis station. A backup copy of all the software shall be provided in CDs.

5.18.5 Flexibility and Scalability

The offered SA system concept shall be flexible and shall permit future extensions to be realised easily as per IEC 61850 standards. Preference will be given to those suppliers who are in a position to provide protection and control devices which can be freely adapted to the application functions required.

5.18.6 System Hardware

5.18.6.1 Operator Station

The main operator station shall be based on an industrial PC hardware and high-resolution full-graphics screen with manufacturers' standard type tested software operating under Windows environment. An black & white printer and a Hard Copy colour printer shall be connected via LAN to the operator station.

Dual station computers shall control the SA system and drive the work stations and other peripherals. One of the station computers shall operate the system in the "on line" state while the other acts as a "redundant hot standby". The standby computer shall be continuously updated and shall immediately take over the SA system duties without interruption or transfer mechanism should the on line operator workstation fail. The Industrial computers shall be supplied in cubicles of protection class IP54 or better along with the GPS clock & switches as required.

Disturbance Records shall be analysed using the installed Disturbance Record Analysis programmes. The Disturbance Records will be collected, over the interbay bus, from the connected IED's by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of Disturbance data or upload them in a pre-programmed manner. The Event printer shall print events spontaneously as they arrive in the main operator station.

Each uploaded data report file shall be reported on one line that shall contain:

- The event date and time
- The name of the event object
- A descriptive text
- The state or value of the object

The information fields above shall be structured in columns for maximum readability.

The hard copy printer shall permit printing of any picture (or part thereof) from the station level PC's using easily accessible commands from the window menus.

The main Station PC`s shall be supplied by the station DC battery and a UPS system with a supply duration of not less than 30 minutes shall be provided to supply the monitor and the printers.

Atleast 32 window annunciator unit shall be directly connected to the main Station PC`s to monitor the same and also to annunciate common station abnormal/fault conditions.

5.18.6.2 Station Inter-bay Bus

The LAN connecting the industrial computer based operator workstations, printers shall be Ethernet 802.3 LAN, Protocol TCP/IP (10 Mbits/ sec or higher) and the physical medium shall be thin Ethernet or fibre optic bus, provided this LAN is kept within the confines of the control room.

The bay control and protection units shall be connected via glass fibre optic cables to a station inter-bay bus using industrial grade Ethernet switches. The station bus according IEC 61850-8 is today mapped to MSS / Ethernet (with priority tagging and with 100 MS/s). The standard is not making any provision on the Ethernet communication infrastructure. To at least ensure a certain level of quality, performance and availability at least the following described criteria's have to be fulfilled concerning the Ethernet switches and topology.

Industrial grade Ethernet switches that fulfill the hardened requirements concerning temperature, EMC and power supply (110 V DC from the station battery) suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g. for later system extension utility has not to rely on one switch supplier only. External switches shall be supplied as they have the advantage that there is no interruption or reconfiguration of the Ethernet ring if one or several bay devices are taken out of service. To increase reliability the Ethernet Switches shall have redundant power supply & shall be powered from two different station batteries.

5.18.6.3 Protection and Control IED's and Local Back-up Control Mimic on 230 kV & 132 kV Level

The bay control IED's, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as protection, commands, bay interlocking, data acquisition, data storage, event and disturbance recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear without any need for separate interposing equipment or transducers.

The numerical bay control IED shall be provided with a minimum of nine (9) configurable (current or voltage) analogue input channels and adequate number of binary input & output channels which are galvanically isolated from the SA system. The channels shall also be individually separated from each other. HV switchgear and instrument transformers shall be directly connected to the bay level IED without any interposing equipment.

The devices shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 255 to conform to the high requirements for operation on the secondary system of HV switchgear.

The 230 kV & 132 kV bay control & protection IED shall have the following features:

- A minimum of 9 configurable analogue channels
- At least 32 binary inputs, 24 signal relays and 2 command relays
- 16 nos. LED's on the front of the unit for indication
- Synchrocheck function
- Power function which can be configured to measure forward or reverse, active or reactive power
- Four (4) independently settable parameter setting groups, settable/selectable locally or remotely via the HMI programme
- 4 line Local Display Unit (LDU or front HMI) on the front of the relay which can display both input as well as measured quantities: frequency, phase currents, phase voltages, active power, reactive power, etc.
- High speed bus serial communication port as per IEC 61850 standards
- Sequence of Events Recorder with a buffer for 256 events and a resolution of 1 msec. The events that are to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to optocoupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.
- Disturbance Recorder function which can record 9 analogue values, 16 Binary signals and 12 analogue channels for internal measurement values. It shall be possible for the Disturbance Recorder function to be triggered by any internal or external binary signal or internal protective function.
- Comprehensive self-supervision
- Battery-free memory back-up of Event and Disturbance Records
- Logic functions (AND, OR, bistable flip flop, etc.)
- Delay/Integrator function

The numerical bay control IED's shall be mounted together with all the relevant bay protective relays in cubicles of Protection Class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LED's shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the substation.

The distributed backup mimic for Local Control shall be installed next to the bay controller IED, which can be used in case of maintenance or emergency or if bay control IED fails. Local bay control via the back-up control mimic on the Control & Protection cubicles shall incorporate the same user safety measures e.g. bay interlocking, synchrocheck, interlock override user guidance, etc. as the station HMI. Local bay control shall be key-locked and the control either from GIS local control panel or station HMI or from remote shall be disabled if the local/remote selector switch on the back-up control mimic is in the 'local' position.

The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function.

Faults in the bay control IED shall be indicated on a front HMI and a message shall be sent to the station level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criteria must be maintained in worst case scenarios also. Further, a single failure must not have any affect on the primary system, which is monitored and controlled.

Only the backup protection can be incorporated in the bay control unit and not the main protections. Main protection shall be provided separately.

All IED`s shall have at least 5 years of successful proven experience in HV applications.

5.18.6.3 Protection and Control IED's of MV Switchgear (33kV and/or 11kV)

Selected mdedium voltage feeders (feeder used for auxiliary supply, incomer feeder from power transformers, and three outgoing line feeders) shall have intelligent electronic devices (IED) for bay control and protection, which shall be integrated with substation automation system of the substation using IEC 61850.

5.18.7 Software Structure

The software package shall be structured according to the SA architecture and strictly divided in various levels. It shall be possible to extend the station with the minimum possible effort. Maintenance, modification or extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the tender.

It shall be the responsibility of the contractor to obtain any license required for the operation software. The contractor shall indemnify the client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

5.18.7.1 Station Level Software

5.18.7.1.1 Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SA functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. The System shall contain a library with standard functions and applications.

5.18.7.1.2 Operating System

Windows Workstation operating system shall be used for the operator station as it supports several standard system features, e.g support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardised, user-friendly look & feel HMI.

5.18.7.2 Bay Level Software

5.18.7.2.1 System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. Its lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage.

5.18.7.2.2 Application Software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They shall form part of a library.

The application software within the control/protective devices shall be programmed in a functional block language.

5.18.8 System Testing

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's, applicable Type Test certificates shall be submitted.

The manufacturing phase of the SA shall be concluded by a Factory Acceptance Test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system. The tenders should prove that they have the required testing tools to test the IEC 61850 based SA system and such tools shall be used and shown to the engineer at FAT.

If the complete system consists of parts from various suppliers, the FAT shall be limited to sub-system tests. In such cases, the complete system test shall be performed at site together with the Site Acceptance Test (SAT).

5.18.9 System functions

5.18.9.1 Control Unit Functions

5.18.9.1.1 Control

The different high voltage apparatuses within the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:

- Commands from different operator places, e.g. from the associated control centre (NLDC), station HMI, or local control panel according to the operating principle
- Select-before execute commands
- Operation from only one operator place at a time.
- Operation depending on conditions from other functions, such as interlocking, synchrocheck, operator mode, or external status conditions.

The control function shall also include:

- Prevention of double operation
- Command supervision
- Selection of operator place
- Block/deblock of operation
- Block/deblock of updating of position indications
- Manual setting of position indications
- Overriding of the interlocking function (Second key switch)
- Switchgear run time supervision

5.18.9.1.2 Status Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in cases when spontaneous position changes have taken place.

Each position of an apparatus shall be indicated using two binary auxiliary normally closed (NC) and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

5.18.9.1.3 Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralised so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall be hard wired/take place via interbay bus.

An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

5.18.9.1.4 Measurements

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

5.18.9.1.5 Event and Alarm Handling

Events and alarms shall be generated either by the switchgear, by the control devices and by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time tagged with a time resolution of 1 ms. The time tagging shall be done at the lowest level where the event occurs and the information shall be distributed with the time tagging.

5.18.9.1.6 Time Synchronisation

The time within the SA shall be set via a GPS Clock Receiver connected directly to the Bay Level LAN. The time shall then be distributed to the control/protective devices via the high speed optic fibre bus. An accuracy of ±1 ms within the station is required.

5.18.9.1.7 Synchronism and Energising Check

The synchronism and energising check functions shall be distributed to the control and/or protective devices and shall have the following features:

- Adjustable voltage, phase angle, and frequency difference.
- Energising for dead line - live bus, or live line - dead bus.
- Settings for manual close command shall be adaptable to the specific switchgear.

5.18.9.1.8 Voltage Selection

The voltages, which are relevant for the synchrocheck functions, depend on the station topology i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronising and energising is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

5.18.9.2 HMI Functions

5.18.9.2.1 General

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log. The Alarm List shall indicate persisting and fleeting alarms separately.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

Following standard pictures shall be available from the HMI:

- Single line diagram showing the switching status and measured values
- Control dialogues
- Measurement dialogues
- Blocking dialogues
- Alarm list, station / bay oriented
- Event list, station / bay oriented
- System status
- Checking of parameter setting

5.18.9.2.2 HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

Object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete value, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state
- Busbar colouring to show live & dead bus.

5.18.9.2.3 Process Status Displays and Command Procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap changers are displayed in the station single line diagram.

In order to ensure a high degree of security against unwanted operation, a special "select – before - execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognise the selected device on the screen and all other switchgear shall be blocked. After the “execution” of the command, the operated switch symbol shall blink until the switch has reached its final new position.

The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated The interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

5.18.9.2.4 System Supervision Display

The SA system shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IED's, communication links, and printers at the station level, etc.

5.18.9.2.5 Reports

The SA shall generate reports that provide time related information on measured values and calculated values. The data displayed shall comprise:

Trend reports:
- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

Historical reports:
- Day
- Week
- Month
- Year

It shall be possible to select displayed values from the database on-line in the process display. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

5.18.9.2.5 Trend Display (Historical Data)

A trend is a time-related follow-up of process data. The analogue channels of all the connected bay level devices on the 230 kV & 132 kV level shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

5.18.9.2.5 Event List

The event list shall contain events, which are important for the control and monitoring of the substation. The time has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer. The information shall be obtainable also from printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices.
- Indication of protective relay operations
- Fault signals from the switchgear
- Violation of upper and lower limits of analogue measured value.
- Loss of communication

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function
- Alarm class

5.18.9.2.5 Alarm List

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. Date and time of occurrence shall be indicated.

The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The alarm date and time
- The name of the alarming object
- A descriptive text
- The acknowledgement state

The operator shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example due to bad contacts or intermittent operation.

Filters for selection of a certain type or group of alarms shall be available as for events.

5.18.9.2.5 Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as

- type of blocking,
- authority
- local / remote control
- NLDC/SA control
- errors,
- etc.,

shall be displayed.

5.18.9.2.6 Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

5.18.9.2.7 User Authority Levels

It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close apparatus)
- Restricted operation (e.g. by-passed interlock)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

5.18.9.3 System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the substation shall be according to the levels specified below:

Function	Typical values
Exchange of display (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s

Presentation of an analogue change in the process display	< 1 s
From order to process output	< 0.5 s
From order to update of display	< 1.5 s

5.18.9.4 System Reliability

The SA system shall be designed to satisfy very high demands for reliability and availability concerning:

- Solid mechanical and electrical design
- Security against electrical interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation, according to IEC 1131-3, of the application software
- Built-in supervision and diagnostic functions
- After sales service
- Security
- Experience of security requirements
- Process know-how
- Select before execute at operation
- Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding to provide immunity against transient ground potential rise

5.18.9.5 Configuration Tools

The configuration of the station HMI shall be made using the operator station working in Windows NT environment. The various functions shall be customised by easy to use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process database and adaptations of the communication configuration data.

A portable Personal Computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

The PC based service & support system shall be used for the following purposes:

- System configuration
- System testing
- Help functions
- Program documentation
- Down- and up-loading of programs
- System commissioning

- Data base management
- Changing peripheral parameters

The service & support system shall be able to monitor data in the running substation control system and to present changing variables on the display screen in graphic representation.

5.18.9.6 Documentation

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

- List of Drawings
- Control Room Lay-out
- Assembly Drawing
- Single Line Diagram
- Block Diagram
- Circuit Diagram
- List of Apparatus
- List of Labels
- Functional Design Specification (FDS)
- Test Specification for Factory Acceptance Test (FAT)
- Logic Diagram
- List of Signals
- Operator's Manual
- Product Manuals
- Calculation for uninterrupted power supply (UPS) dimensioning
- High quality SCD file

5.18.9.7 Indicating Meters in Local Back-up Control Panels

Each circuit shall be equipped with Indicating meter for measurement of three phase currents, voltages, frequency, power factor, active and reactive power. Repeat pulse outputs are to be provided from all energy meters, where specified.

5.18.9.8 Trip Circuit and Power Supply Supervision

Trip circuit supervision relays shall be provided to monitor each of the trip circuits of circuit-breakers in the relay panel and each relay shall have sufficient contacts for visual/audible alarm and indication purposes.

The trip circuit supervision scheme shall provide continuous supervision of the trip circuits of the circuit-breaker in either the open or closed position and independent of Local or Remote selection at the local operating position. It shall be suitable for use in single and three pole tripping schemes as appropriate.

Relay elements shall be delayed on drop-off to prevent false alarms during faults on d.c. wiring on adjacent circuits, or due to operation of a trip relay contact.

Series resistances shall be provided in trip circuit supervision circuits to prevent maltripping of a circuit-breaker if a relay element is short circuited.

Relay alarm elements should be equipped with self resetting flag indicators.

Where specified, time delayed power supply supervision relays shall be provided to monitor the duplicated d.c. power supplies for tripping, closing, CB fail, busbar protection etc. within a relay panel. An alarm shall be given if either supply voltage falls below 70% of nominal voltage for a period in excess of 3 secs. The relay shall be equipped with a self resetting flag indicator, and shall be suitable for continuous operation at 125% of nominal d.c. voltage.

5.18.9.9 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 direct use of auxiliary contacts on busbar selector switches.

5.18.9.10 Availability Calculations

The contractor shall submit availability calculations for the offered substation automation system.

5.19 DIAGRAMS

The Contractor shall submit schematic diagrams for consideration of the Engineer within six months of the Contract commencement date. Prior to preparation of schematic diagrams, the Contractor shall provide single line, block and logic diagrams in order to agree the circuit schemes and operating modes.

The Contractor will be provided with a set of drawings for each Substation as soon as possible after award of Contract. As part of the Contract documentation, the Contractor shall provide integrated sets of complete drawings (schematic and wiring diagrams, cable schedules, etc).

5.20 CURRENT TRANSFORMER CALCULATIONS

The Contractor shall submit to the Employer detailed calculations substantiating the parameters of the current transformers he proposes to provide. They shall be presented within six weeks of the Contract commencement date.

5.21 DIGITAL FAULT AND DISTURBANCE RECORDER [DFDR] (Applicable for Faridpur new 230/132kV GIS)

This specification and Schedule T3: Employer's Requirement, the schedule of requirements states the requirements for the supply, installation and commissioning, of a Digital Fault and Disturbance Recorder [DFDR] at new Faridpur 230/132kV GIS substation. Installation, testing & commissioning of DFDR shall be done by the DFDR engineer (s) of the DFDR manufacturer(s).

Make of DFDR shall be Qualitrol (UK) / SEL (USA)/ Siemens (Germany) for standardization of operation performance, facilities and spare requirements. The DFDR shall have the following features:

The DFDR shall have the following features:

(a) The equipment shall be an independent stand alone system to monitor analogs and digital signals from all 230kV feeders including transformer and bus-coupler bays that requires to be monitored.

(b) The manufacturer shall prove the system reliability of 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 recommendations and type test reports from internationally acclaimed laboratories.

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

(d) The acquisition system or it's storage unit shall not be based on a PC platform.

(e) For new substation an Independent DFDR System shall be equipped with the requirement mentioned in Schedule T3: Employer's Requirement of Volume 3 of 3.

(f) System shall be equipped to monitor, detect and record simultaneously Fast transient faults (short term) and Slow phenomena disturbances (Long term) like power swing, frequency variation, voltage drop, etc. covering all the required feeders.

(g) 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 terms) transient monitoring and from 1Hz to 500Hz for Slow phenomena (Long terms) monitoring in order to detect and record Fast (short terms) and Slow phenomena (Long terms) events.

(h) 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.

(i) The graphical data should be recorded in respect of all feeders simultaneously (snap shot image).The recording should contain the data prior to the event, post event including the dynamic length of the event / fault without any alterations.

(j) The system should possess a library of sensors (triggering criteria), which should be selected by the user and 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.

(k) The recordings shall contain the graphical data of Physical inputs (voltage, currents, digitals) and virtual inputs.[eg. Frequency, dp/ dt , dq/dt (3 Phases / Single Phase),RMS values etc..]

(l) The DFDR shall be able to communicate with Local and / or Remote Master Station using Master communication and Analysis software. This software should permit the user either locally or remotely to down load the recorded data, to ascertain the system operational status, change parameters etc.

(m) 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.

(n) The following functions shall be performed by the DFDR, 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.

(o) System shall be able to calibrate at site, and the required menu driven software and other required accessories shall be supplied along with a Note book computer and color printer etc.

(p) The systems shall be equipped for time synchronization by the external GPS clock receiver for real time synchronizing (including Antenna).

(q) Local printing facility shall be provided with the system.

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

(s) Provision for Power Quality monitoring or continuous monitoring (periodical recording) shall be made available for at least 4 feeders.

5.22 Energy Meter (Tariff Metering) :

Meter requirement:

1. Programmable meter
2. Adjustable different tariff
3. 110-400V flexible input voltage setting
4. 1(10) A current rating
5. Accuracy class to be ±0.2 for kwh and ±0.5 for kvarh
6. RS232/485 Port for Medem interface
7. Standard metering protocol for remote interface

8. Data storage of 16 channel@30min interval and of 90days
9. Optical head and software to upload and download of meter data
10. Password protection for programming and for configuration
11. Configurable display, including meter ID, Power quadrant display etc .
12. Provision for quick reading scroll, reset etc(Programmable)

Additional requirement:

1. Online test facility of meter(with TTB) and with Security Sealing Provision.
2. TTB's should be at the suitable accessible panel front location with meter
3. Meter cabinet should be exclusive for tariff metering only and have sufficient Security Sealing provision, provided with 220V, 5A two pin socket outlet for modem power, Auxilliary bias power, Testing Equipment power etc.
4. All main metering CT, VT should be terminated to metering panel directly including star point(4 wire).
5. Backup metering circuit may be shared for other purpose.
6. VT MCB(both main and backup) should be located in the metering panel. Down stream VT MCB rating should be less than that of up stream.
7. All CT & VT terminals shoud have Security Sealing provision.

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
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-arithmatic
29	Line frequency

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-arithmatic
9	Line frequency

Load profile(Cumulative meter reading) and Instrumentation profile Data in the following format should be stored in each 30 min interval for at least 100 days.

Interval Data(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

Interval Data(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-arithmatic
Date:1/31/2015				
13:45	0.0008	0.0004	0.0004	-0.7002

Self Read Feature for at least 12 month’s billing history.

SECTION 6

AUXILIARY POWER AND CONTROL CABLES

TABLE OF CLAUSES

SECTION 6

AUXILIARY POWER AND CONTROL CABLES

6.1 SCOPE

A complete cabling system for the substation 415/230 V auxiliary power requirements and the control and protection multicore cabling shall be designed, provided, installed and commissioned by the 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 Employer.

The Contractor shall provide an installation in accordance with the best modern practice and complete in every detail for continuous operation.

Cabling areas will include those which have natural ventilation. Cabling shall therefore be designed for the maximum ambient temperatures expected.

To cater for future requirements, adequate provision shall be made for the associated cables in respect of trench sizes, space for future racks or trays and numbers of cables permitted in areas or spaces required for future equipment.

The Contractor shall submit to the Employer 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 International Electrotechnical Commission (IEC) Standards and Recommendations, or any other internationally recognised standards, subject to the approval and acceptance of the Employer.

6.4 CABLE INSTALLATION

6.4.1 General

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

Cables shall be satisfactory for operation under the atmospheric and climatic conditions prevailing at the site and under such variations of current, voltage and frequency as may be met under fault and surge conditions on the system.

Cables shall be derated to allow for the likely number of cables following a given route.

The methods of installation shall be as follows:

(a) In concrete trenches
(c) In ducts
(d) On cable racks, trays or ladders

Control and instrumentation cables shall be screened/shielded to minimise interference, where necessary.

6.4.2 Installation Criteria

Specific requirements shall be as detailed in the Project Requirements.

System security shall be achieved by ensuring that cables are segregated or separated from each other as appropriate. Segregation shall be achieved by laying cables associated with any one high voltage circuit of a pair on separate trays or racks at least 600mm apart from the cables of the other of the pair with an airspace, but not necessarily a physical barrier, between them.

In general, to minimise interference, control cables and instrumentation cables shall be separated from power cables.

The following group classifications will be allocated for each cable:

i) Group A: Single core power cables,
ii) Group B: Multicore power cables,
iii) Group C: Multicore control cables and protection cables,
iv) Group D: multipair control and instrumentation or indication cables.

In general, single core (Group A) and multicore (Group B) power cables shall be allocated to separate racks. In a similar manner, multicore control (Group C) and multipair (Group D) instrumentation cables shall generally be allocated to separate trays.

There shall generally be a minimum separation of 600 mm between instrumentation cables (Group D) and power cables (Groups A and B), and a minimum separation of 300 mm between control cables (Group C) and power cables (Groups A and B). However, both these separation distances may be reduced where the two types of cable only run in parallel for a limited distance, provided the 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 Electrotechnical 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 Employer.

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 limitations
- Sizing cables in accordance with length grouping, ambient temperature and current rating

- Recording estimated lengths and later measured lengths for each cable
- Progressing the cable installation
- Producing and progressing cable schedules, cable termination schedules, and support steelwork schedules and drawings

All necessary 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 factors.

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 temperature, followed by the initial asymmetric peak current, followed by the thermal steady state r.m.s. fault current for the total duration required for the associated main and back-up protection to operate and isolate the circuit. When protected by a circuit breaker which is not of the current limiting type, the cable shall withstand the maximum fault current, including asymmetric peak, for at least 3 seconds without damage.

For 415V motor supply cables the rating shall be based upon the duration of the 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 giving the lowest cable rating shall determine the cable size.

The sizes of all cables shall be submitted to the Employer for approval and the Employer may require the 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 retardant characteristics of BS 4066 and IEC 60332.

PVC sheathing shall have flame retardant properties such that the Oxygen Index is not less than 30 when tested in accordance with A.S.T.M. 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 fungal and insect attack, or made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens.

Each cable drum shall bear a distinguishing number on the outside of one flange. Particulars of the cable, i.e. voltage, conductor size and material, number of cores, type, length, gross and net weights shall also be clearly shown on one flange. The direction of rolling shall be indicated by an arrow on both flanges. The method of drum marking shall be to the Employer's approval.

Cable spare lengths shall be wound on to steel drums before they are handed over to the Employer's stores.

6.5.5 Sealing and Drumming

Immediately after the Works tests, both ends of each cable length shall be sealed by means of a shrinkable cap and the end projecting from the drum shall be adequately protected against mechanical damage during handling. The ends of each drum length of multicore cables shall be masked red and green in accordance with BS 6346 or BS 5467.

6.5.6 Spare Cable

Spare cable and accessories, as detailed in the schedules, are required to be included in the Contract.

6.5.7 Jointing Accessories

Cables shall be installed in continuous lengths and straight through jointing between shorter lengths will not be permitted.

Jointing accessories shall include all necessary internal and external fittings, insulating materials, soldering metal, glands, filling and drain plugs, armour clamps, earth bonding terminals and filling compounds as appropriate.

Mechanical glands for the termination of elastomeric or thermoplastic insulated cables into straight-through joints and termination accessories shall meet the requirements of BS 6121 and shall be correctly designed for the termination of the armouring. The gland shall not only adequately secure the armour to provide efficient electrical continuity but shall also provide a watertight seal between the oversheath and the inner extruded or taped bedding to prevent the ingress of moisture. All glands shall be fitted with a substantial earth bond terminal.

The armour clamping device shall be capable of clamping the cable armour so that the clamp withstands any short circuit current from the armour wires, through the gland body to the integral bonding connector.

Sealing end porcelains shall be free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth and hard, completely cover all exposed parts of the porcelain and for outdoor types shall be a uniform shade of brown.

Porcelains must not engage directly with hard metals and, where necessary, gaskets shall be interposed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

Sealing ends and fittings shall be unaffected by atmospheric conditions, proximity to the coast, fumes, ozone, acids, alkalis, dust or rapid changes of air temperature between 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 0.6/1kV.

These 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 flexible copper conductors shall not be less than 1.5mm^2 ; 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 conductor size shall be not less than 4.0 mm2 copper for CT connections.***

The second type designated "signal cable" is defined as those cables carrying milliamp, analogue or digital signals at low voltage levels (50V d.c. maximum) used on instrument and Logic Transmission Systems. These cables shall be multiple twisted pairs, screened and PVC covered with conductors sized 0.5mm^2 minimum (1/0.8mm or 1/0.9mm diameter). The use of cable cores shall be such that each plant analogue signal is transmitted in a twisted pair. Under no circumstances shall the signal positive be in a different twisted pair to the negative. 20% spare capacity shall be included in all multiple twisted pair cables. The combinations of multiple twisted pair cables used throughout the Plant shall be restricted to 2, 5, 10, 20, 30, 50 and 100 pairs.

Inductive interference between primary and secondary cables due to load, switching or unbalanced fault conditions associated with the primary circuit shall be avoided. The more sensitive telephone, communication, analogue and digital circuit cables shall be spaced at least 600mm from power cables.

6.6.2.2 Multicore Control Cables

Cables shall comply with the construction hereabove 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 voltage rating 0.6/1 kV. Standard designs shall be for cables with 2, 3, 4, 7, 12, 19, 27 and 37 cores, and single strand conductors will be accepted up to 1.5 mm^2 .

All these cables shall have galvanised steel wire armouring.

These cables shall be used where a low impedance is essential, e.g. for the secondary wiring of current and voltage transformers and for circuit breaker and contactor control circuits.

6.6.2.3 Multipair Instrumentation Cables

Multipair instrumentation cables shall be provided in accordance with industry standards.

These cables shall have solid copper conductors, typically of 0.9 mm diameter laid in twisted pairs, triplets or quads. The cables shall be polyethylene or XLPE insulated. They shall have galvanised steel wire armouring.

Cables shall be provided with either an overall metallic tape screen or individual tape screens round each conductor bundle to reduce interference from adjacent circuits.

These cables shall be used for circuits with a voltage rating not exceeding 125 V to earth and a current rating not exceeding 20 mA, where considerations of interference and cross-talk are of great importance. Typical applications include communications, computer signals, transducer circuits and alarms.

6.6.2.4 Oversheaths

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

6.6.2.5 Telephone Type Cables (TWPVC)

i) Construction

Multipair cables with l/0.9mm tinned copper conductors complying with IEC 60228, PVC insulation, individual twisted pairs, PVC bedding, single wire armoured and low smoke PVC sheathed overall.

ii) Insulation

PVC insulation shall be "Hard Grade" to BS 6746 with a radial thickness of 0.7mm nominal 0.57mm minimum. Minimum insulation resistance per 1000 metres of conductor at 20°C shall be 10,000 Megohms.

iii) Laying Up

The insulated conductors shall be uniformly twisted together with a right hand lay to form a pair. The length of lay is not to exceed 150mm and the lays for each adjacent pair are to differ from one another in length. In any case, the length of lay of the pairs shall be such that any cross-talk from pair to pair is the least possible.

iv) Core Identification

The insulation of the cores shall be colour coded in accordance with IEC 60189-2 for 20 unique cabling elements (pairs) as described in Appendix A of IEC 60189-2.

6.6.2.6 Pilot Cable

Telephone type cable laid in the ground alongside HV power cables shall take into account the effects of induced voltages.

6.7 STRAIGHT THROUGH JOINTS

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

- In concrete trenches
- In ducts
- On cable racks, trays or ladders

Concrete trenches shall be provided in switchrooms. Cables shall be installed in a manner which permits the required ratings and with due regard to the number of cables following a given route, including future plant extensions.

All cables routed under roads and access ways usable by vehicular traffic shall be installed in ducts.

At all such crossings spare ducts shall be installed; the number of spare ducts shall be two, or 20% of the total number of ducts installed at each crossing, whichever is greater.

Mechanical protection to the Employer's approval shall be installed at all points where the cable is vulnerable to mechanical damage. Locations where this protection shall be installed shall include all points where cables pass through a wall, floor, side or top of a cable trench.

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

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

6.9 CABLES DRAWN INTO DUCTS

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

Ducts shall be of rigid PVC and shall be surrounded by l50mm minimum thickness of concrete.

Before pulling cables through ducts, the 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 Contractor before back-filling.

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

6.10 CABLES INSTALLED IN CONCRETE TRENCHES

The cable trench system shall be designed by the Contractor to the approval of the Employer. It shall be complete with removable covers and shall comply with the building and civil works Section.

All cables routed in concrete trenches shall be suitably supported by means of cleats or racks and raised from the trench floor by means of suitable spacers. All cables shall be run in a neat and orderly manner and the crossing of cables within the trench shall not be acceptable without the prior approval of the Employer.

The Contractor shall be responsible for removing and replacing the trench covers free of charge during the execution of his work as directed by the Employer.

6.11 CABLES SUPPORTED ON RACKS, TRAYS AND LADDERS.

6.11.1 General

All single core and multicore main power cables shall be installed in cleats or saddles fixed at intervals. Multicore power cables shall be installed on trays, racks or ladders but segregated from other cables on the same tray by a space of 300 mm.

All cables shall be installed on trays with adequate racks, clamps, cleats or ties to avoid excessive 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 Employer to give his approval for all main and subsidiary routes before installation commences.

Ample allowance shall be made in the design for additional cabling for future extensions.

Racks and trays shall be secured to channel or similar inserts installed in accordance with Building and Civil works section.

All cables shall be run with a particular regard to neatness of appearance. Multiple runs shall be arranged so that cables entering or leaving the run do so in a logical manner.

Trays and supporting steelwork shall be securely bonded and grounded to the main earthing/grounding system. Bonding and grounding connections shall be adequate to carry prospective fault currents without exceeding thermal or voltage limits.

6.11.2 Supporting Steelwork

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

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

On all main cable runs, supporting structures shall be designed and drilled to accommodate additional cable racks or cleats to the extent of 20% of cables installed under the Contract and those required for known future extensions. The spacing between supporting structures shall be not greater than 1m unless otherwise approved by the Employer.

In cases where cables or their supports must be fixed to structural metal work, care shall be taken to avoid eccentric load transfer to beams or other structural metal. Also, local overloading or deformation of structures shall be avoided. The Contractor shall, if required, demonstrate that the loading resulting from the attachment of cabling steelwork has been taken into account in the steelwork design.

6.11.3 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 1m from its terminal gland to prevent stressing the termination, and on vertical runs passing through floors, immediately above the floor.

6.11.4 Trays, Racks and Ladders

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

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

(a) Up to l6mm^2 - double layer touching.
(b) 25mm^2 to 70mm^2 - single layer touching.
(c) Above 70mm^2 - single layer with 25mm (minimum) spacing.

All cable trays shall be perforated.

All trays, racks and ladders shall be galvanised to a thickness not less than 1.6 mm and shall be PVC coated in exposed areas. The erection of steelwork, trays, racks or ladders shall not proceed until the Employer's approval for such has been obtained.

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

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

6.12 TERMINATIONS

6.12.1 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 termination location in the panel.

Cable glands shall be used at all equipment to support the weight of cable from the terminations and to seal the cable to the equipment, unless otherwise approved by the Employer.

PVC, XLPE, silicone rubber and PTFE insulated cables shall be terminated via glands to BS 6121. Glands where water may impinge on cables shall be type ElU, with inner and outer seals and armour clamp. Unarmoured single core cables in these areas shall have type A2 glands.

Glands in indoor locations with the exceptions as noted above shall be type C for armoured cables and type A2 for unarmoured single core cables.

PVC shrouds shall be supplied and installed over each gland.

6.12.2 Power Cables

The 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 Employer and, if found necessary, the Contractor shall carry out the reversal of phase connections. Connections to electric motors shall be made as specified. Where motors have tails rather than bushings, a heat shrink or equivalent PVC tube for insulation of the crimp joint shall be provided.

Where insulated glands are provided, the Contractor shall ensure that the insulation is maintained after jointing the cable and shall, if required, demonstrate this to the satisfaction of the Employer.

The tails of two or three or four core cables in air insulated terminations shall be identified by a band of approved tape of appropriate colour over the self-sealing tape.

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

6.12.3 Mineral Insulated Cables

The MICS cables shall be terminated with pot type seals in Universal ring type glands utilising cold plastic compound of an approved type. Accessories and methods of anchoring the extension sleeving shall be to the approval of the Employer. All MICS cable terminations shall be complete with high temperature neoprene sleeves of sufficient length over conductors and sundries. All MICS seals shall be tested not less than twenty-four hours after completion with a 1000V insulation resistance tester and a reading of greater than 10 Mohms must be obtained before conductors are connected at any apparatus.

The Contractor shall provide the necessary compound of approved grade and necessary MICS cable glands. Where the ambient temperature is expected to exceed 50°C, special seals shall be used, details of which shall be approved by the Employer.

6.13 TERMINATING AND JOINTING CONDUCTORS

Compression (indentation) type cable lugs and ferrules shall be provided and all necessary tools, including dies and other materials for making compression joints, shall be provided by the 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 exception of flexible conductors having wires 0.3mm or smaller which shall be fitted with crimps. Not more than one conductor shall be terminated in each clamp.

6.14 CORE IDENTIFICATION

A uniform core identification system shall be used throughout the Station. The following clauses outline the broad requirements but the exact implementation shall be agreed with the Employer.

Approved numbered ferrules shall be supplied and fitted to every cable core of control and instrument cables at each termination. The ferrules or sleeves shall be of interlocking ring insulating materials such as plastic which shall be black engraved on yellow background and have a glossy finish. The ferrules or sleeves shall be unaffected by oil or damp. Identification marks on self - sticking cloth shall not be used. The ferrules shall be of “O” or “D” cross section. Ferrules of “C” type cross section shall not be used.

Single d.c. wires shall be identified by a red or blue coloured ring (positive or negative polarity) followed by the identification of the polarity concerned (instrumentation, klaxon, alarm, etc.).

Direct a.c. circuits shall be identified by a yellow end piece followed by an identification of the phase concerned.

Wiring for secondary circuits of voltage transformers shall be identified by a grey end piece and wires in current transformer secondary circuits shall be identified by a green end piece. This identification shall be completed by a terminal index.

All markings for terminal blocks, cables, cable conductors and wiring shall be located on the corresponding fault finding drawing.

Characters suitably marked 'TRIP' in white shall be fitted on all wires associated with trip circuits.

A common system of ferrule numbering shall be adopted such that ferrule numbers at terminations shall agree with ferrule numbers on the internal wiring of equipment.

6.15 CABLE IDENTIFICATION AND SCHEDULES

The Contractor shall prepare and submit computerised cable schedules, the content and style of which shall be to the general approval of the Employer. These shall include cable identification numbers for all cables except those provided for lighting and small power circuits and those which are connected to the load side of distribution boards for lighting and small power circuits.

The cable identification number system shall be such as to give a brief general indication of the type and function of individual cables and shall be approved by the Employer.

The 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:

(a) By cable identification number only
(b) By type and size of cables
(c) By function of cable
(d) By main LV ac and DC. Switchboard, actuator boards.
(e) By agreed electrical and mechanical plant functional groups.

The 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 Employer to access, display, print and edit the schedules. The schedules shall be accessed by simple interactive dialogue using 'menu-selection' or other approved procedure.

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

Each end of every cable, except those provided for lighting and small power circuits and which are connected to the load sides of distribution fuse boards, shall be identified with a separate cable reference number fitted in a suitable position under the cable termination.

Where cables enter and leave ducts or pipes, suitable identification markers shall be fitted.

The materials of the markers and fastenings shall be such as to avoid corrosion or deterioration due to incompatibility of materials and shall ensure permanent legibility.

6.16 INSPECTION AND TESTING

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

SECTION 7

EARTHING SYSTEMS, ELECTRODES CONNECTIONS

TABLE OF CLAUSES

SECTION 7

EARTHING SYSTEMS, ELECTRODES CONNECTIONS

7.1 SCOPE

These clauses describe the General Requirements for the Earthing and Lightning Protection and shall be read in conjunction with the Project Requirements and Schedules.

7.2 REFERENCES

7.2.1 American Standards

ANSI/IEEE/std80	IEEE Guide for Safety in AC Substation Grounding
ANSI/IEEE/std81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grounding System

7.2.2 German Standards

DIN VDE 0141	Earthing Systems for Power Installations with Rated Voltages above 1 kV

7.2.3 British Standards

BS 1432	Specification for copper for electrical purposes: high conductivity copper rectangular conductors withdrawn or rolled edges.
BS 1433	Specification for copper for electrical purposes. Rod and bars
BS 2871	Specification for copper and copper alloys. Tubes
BS 2874	Specification for copper and copper alloy rods and sections (other than forging stock).
BS 4360	Specification for weldable structural steel
BS 6360:	Specification for conductors in insulated cables and cords.
BS 6651	Protection of Structures against Lightning
BS 6746	Specification for PVC insulation and sheath of electric cables.
BS 7430	Code of Practice for Earthing

7.2.4 International Standards

ISO 427	Wrought copper-tin-alloys - chemical composition and form of wrought productions.
ISO 428	Wrought copper-aluminium alloys - chemical composition and forms of wrought production.
ISO 1187	Special wrought copper alloys - chemical composition and forms of wrought products.
ISO 1137	Wrought coppers (having minimum copper contents of 99.85%) - chemical composition and forms of wrought products.

7.3 GENERAL

An earthing system generally in accordance with the requirements of IEEE 80 and BS 7430 shall be designed under this Contract. Installation and the supply of all materials and equipment shall also be included. The earthing system shall include earth electrodes to provide the connection to the general body of the earth and all conductors and connections to all electrical equipment and metallic structures on the site. The earth electrodes shall limit the potential rise under fault conditions and buried conductors shall be provided to limit potential differences on the site and adjacent to the site to ensure safety to people and animals.

Protection for all electrical equipment against lightning shall also be provided.

7.4 EXTENT OF WORK

The Work under this Section comprises the site testing, design, supply and installation, including excavation, backfilling and temporary reinstatement, of earthing systems and connections to electrical apparatus at each substation. The scope of work also includes earthing of substation building.

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

The preliminary Bid design shall be based on a value of 100 ohm-m soil resistivity.

Not later than one month after the site has been handed over for access, the Contractor shall carry out an earth resistivity survey of the sites and report in writing to the Engineer in accordance with the approved programme. The report shall detail the methods and instruments used and the results of the surveys. Based on the results the Contractor shall include in the report his proposals for the resistivities to be used in the design of the earthing system.

The surveys shall show the variation of resistivity across the site and with the depth below the site. The Contractor shall consider if there is a need to model the resistivity in two layers and if there is any advantage in the use of deep rod electrodes.

The surveys shall also determine the depth and nature of any underlying rock, which may limit the depth for driving earth rods or if boring will be necessary for installing earth rods.

The weather conditions prior to and at the time of the surveys shall be recorded in the report and an assessment made of the seasonal variations in resistivity based on meteorological data for the area. The programme for the project should, as far as possible, time the resistivity surveys to take place during a dry season.

The report should also state if there are any indications that the ground is corrosive to bare copper.

The report shall be approved by the Engineer before proceeding with the design of the earthing system.

7.6 FAULT CURRENT AND DURATION

Each site shall be provided with an earth grid of buried conductors designed for an earth fault current as specified in clause 1.2.1 of section-1 of this volume(2 of 3). The preliminary earthing design shall be such that the potential rise shall not exceed 5 kV.

7.7. EARTH ELECTRODE SYSTEM DESIGN

7.7.1 Design Calculations

The design of the earth electrode systems shall be based on the approved earth resistivity data and the system fault currents and their duration.

The design calculations shall be to the approval of the Engineer and shall be based on the methods given in the standards listed. The calculations shall include the following parameters:-

(a) earth resistance of the whole system and of its components
(b) earth potential rise (GPR)
(c) step, touch and mesh potentials inside and outside the perimeter fence
(d) requirements for a high resistance surface layer
(e) conductor ratings

Earthing points shall be provided such that the combined resistance of the earth grid and all other earthing points does not exceed 0.5 ohm during the dry season.

The earth potential rises shall not exceed the CCITT limits appropriate to the classification of the system unless special precautions are taken to cater for transferred potentials.

Step, touch and mesh potentials shall be within the permitted limits calculated in accordance with the standards given in IEEE 80-2013 for the proposed surface layer.

For calculating the conductor size of main mesh a current distribution of 50%-80% may be considered, In case direct current is allowed to pass through mat in any mode of operation, allowance for the same shall be made in design.

It shall be noted that, Finite element analysis of the ground grid conductors and rods shall be done by the contractor using suitable software supports IEEE 80-2013 standard.

7.7.2 Earth Electrode

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

(a) a system of interconnected rods driven into the ground
(b) a mesh system of bare conductors buried in the ground
(c) structural metalwork in direct contact with the ground
(d) reinforcing steel in buried concrete
(e) a system of bare conductors buried near the surface of the ground outside the perimeter fence

7.7.3 Mesh System

The mesh system shall be designed in accordance with sub-clause 7.7.1 above to limit touch, step and mesh potentials taking into account the combined length of the mesh conductors, other buried conductors and rods but excluding any buried conductors outside the perimeter fence. Due regard shall be given to non-linear distribution of the fault current giving rise to the highest potentials at mesh corners.

The rating of the mesh conductors shall be compatible with the fault currents after allowing for parallel paths of hard drawn high conductivity copper strip with a minimum conductor size of 150 mm^2.

The conductor shall be installed in trenches excavated by the Contractor to a depth of 500mm. The system will be installed after all foundations have been laid and the site filled to 100mm below finished level. When the earthing grid has been laid and backfilled, bricks will be laid up to finished site level. Where the excavated material is rocky or may be difficult to consolidate, the backfilling shall be carried out using other material to the approval of the Engineer. The cost of such material shall be deemed to be included in the Contract.

7.7.4 Interconnected Rods

If the design calculations show that a mesh alone is unable to limit the potentials to the required values, then the mesh shall be supplemented by the use of interconnected earthing rods driven into the ground or installed in bored holes.

Rods shall be installed inside the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. (The spacing between rods shall not be less than their length, unless rating considerations determine otherwise). The copper rod electrodes of 15mm diameter shall be interconnected in groups of four to eight rods by insulated copper conductors and non-ferrous clamps to form a ring. Each group shall be connected to the mesh by duplicate insulated copper conductor via disconnecting test links.

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

Rods installed in bored holes may be used to reach lower resistivity ground strata at depths beyond the reach of driven rods or where rock is encountered and it is not possible to drive rods. After installing the rod, the bored hole shall be back-filled with a low resistivity liquid mixture, which shall not shrink after pouring, to ensure good contact between the rod and the ground for the life of the installation.

The resistance and rating of individual rods and the combined resistance of the groups of rods in the proposed design shall be calculated and the rating of the interconnecting conductors shall not be less than that of the group of rods with a minimum conductor size of 75 mm^2.

The calculation of potentials in the design of the complete installation shall be made without the group of rods with the lowest estimated resistance to simulate the condition with the group disconnected for testing.

7.7.5 Other Conductors

As an alternative to rods to supplement a mesh, additional bare copper conductors with a cross-section area of not less than 150 mm^2 may be used. They shall be buried in the ground within the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. Such conductors may be laid below the mesh, below foundations or in areas where there is no plant. It shall be shown by calculation that the step potentials are low in such areas.

The conductor shall be in a ring, or a part of a ring, with at least two widely separated connections to the mesh or other parts of the earthing system.

7.7.6 Reinforcing Steel

The reinforcing steel in the foundations of buildings containing the primary electrical equipment may be used as auxiliary electrodes, subject to the approval of the Engineer. The Contractor shall show in the design calculations that the fault currents and D.C. stray currents will not damage the structure.

Steel reinforcing mesh in the floors of the building may also be used for the control of step and touch potentials within the building, subject to the approval of the Engineer.

7.7.7 Conductors Outside Perimeter Fence

If the design calculations show that the step and touch potentials outside the perimeter fence or wall exceed the limits, then additional bare conductors shall be buried in the ground outside the fence in the form of rings encircling the whole site.

The distance of the conductors from the fence and the depth shall be determined in the design to ensure that step and touch potentials are within the limits.

The minimum conductor size shall be 75 mm^2 copper and shall be connected to the fence or the mesh with 75 mm^2 conductors at each corner of the site and at intervals of not more than 100 m. These conductors shall not be included in the calculations called for above.

7.8 DESIGN OF EARTH SYSTEM

7.8.1 Earth System

An earth system shall comprise the following components: -

(a) the conductors between the earth electrode system and the main earth bar
(b) the main earth bar

(c) the conductors between the main earth bar and the metallic frames, enclosures or supports of electrical equipment
(d) the conductors between structural metalwork and non-electrical equipment and the main earth bar

The rating of earth system conductors connected between an item of electrical plant and the earth electrode system shall be sufficient to withstand the fault currents and duration, after allowing for the parallel paths through the earth system conductors, with any one conductor disconnected.

The design of earth system shall take into account the corrosiveness of the soil based on the soil survey.

The design comprising all the above mentioned items shall be submitted to the Engineer for approval within four months of the award of Contract.

7.8.2 Connection of System Neutrals and Earth

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

The earth electrodes of a neutral earthing point shall be arranged in two groups with a conductor from each group to a test link and there shall be duplicate bare copper conductors of cross sectional area not less than 150 mm^2 from each test link to the earth grid. The duplicate connection may be in the form of a ring.

Neutral earthing connections between the substation system (transformer) neutral and the test links shall be of bare copper tape, secured and supported on stand-off insulators so that there is no contact between copper tape and transformer tank.

Neutral earthing conductors shall normally be buried directly in the ground but where necessary, they may be cleated to walls, fixed to cable racks or laid in the cable trenches.

7.8.3 Main Earth Bar

The main earth bar shall be in the form of a ring or rings of bare conductors surrounding, or within, an area in which items to be earthed are located. Where two or more rings are installed, they shall be interconnected by at least two conductors which shall be widely separated.

The main earth bar, or parts thereof, may also form part of the earth electrode system, providing this is bare conductor.

Each main earth bar shall be connected by at least two widely separated conductors to the earth electrode system.

The minimum conductor size for the main earth and interconnections between earth bars and the earth electrode system shall not be less than 150 mm^2.

7.8.4 Electrical Equipment Tank and Structure Connections to Earth

Connections between: (a) all HV electrical equipment and (b) LV electrical equipment comprising substantial multi-cubicle switchboards and the main earth bar shall be duplicated. The bare copper conductor size shall have a minimum cross section area of 150 mm^2.

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

Surge arresters installed for the protection of transformers shall be connected by low reactance paths both to the transformer tanks and to the earth grid.

An earth mat shall be installed at all operating positions for outdoor HV equipment manual operating mechanism boxes and local electrical control cubicles to ensure the safety of the operator. The mat shall be directly bonded to the cubicle and the conductors forming the mat and the bonding connection shall have a minimum copper cross-section area of 75 mm^2.

Galvanized structures comprising bolted lattice components shall not be used as the sole earth connection path to post and strain insulators.

Buildings containing electrical equipment shall be provided, at each level, with a ring of earthing conductors which shall have duplicate connections to the earth grid outside the building. The frames of all switchgears, control and relay panels and other electrical equipment and exposed structural metal work shall be connected by branches to a ring. The ring and branch conductors shall be of the same material as the earth grid. Strip run within buildings, inside cable trenches or above ground level on apparatus shall be neatly supported in non-ferrous clamps.

Connections between other LV electrical equipment and the earth bar need not be duplicated. The single conductor shall be rated to withstand the fault rating of the equipment.

7.8.5 Connections to 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 150 mm^2.

Individual components of metallic structures of plant shall be bonded to adjacent components to form an electrically continuous metallic path to the bonding conductor.

Small electrically isolated metallic components mounted on non-conducting building fabric need not be bonded to the main earth bar.

7.9 MATERIALS AND INSTALLATION

The GTP of Earthing material along with wits technical parameters as used in the design and the methodology of earthing system installation shall be submitted for approval.

7.9.1 Conductors

Conductors shall be of high conductivity copper in the form of circular conductors stranded to IEC 60228 or solid rods or bars to BS1433.

Conductor sheaths shall be of PVC to meet the requirements of BS 6746 Grade TM1 or IEC 60502 Grade ST1 with a minimum thickness of 1.5 mm.

Buried conductors which are not part of the earth electrode system shall be PVC sheathed circular stranded cable.

Bare strip conductors only shall be used for earth electrodes or voltage control meshes.

Conductors buried in the ground shall normally be laid at a depth of 500 mm in an excavated trench. The backfill in the vicinity of the conductor shall be free of stones and the whole backfill shall be well consolidated. Conductors not forming part of a voltage control mesh shall be laid at the depth required by the approved design and, in the case of PVC sheathed conductor, at the same depth as any auxiliary power or control cables following the same route.

All conductors not buried in the ground shall be straightened immediately prior to installation and supported clear of the adjacent surface.

7.9.2 Earth Rods

Earth rods shall be driven to a depth below the ground water table level, to be determined by the Contractor during soil investigation and survey of site.

The earth rods shall be of hard-drawn high conductivity copper with a diameter of not less than 15 mm with hardened steel driving caps and tips. The rods should be as long as possible but couplings may be used to obtain the overall depth of driving required by the design.

The rods shall be installed by driving into the ground with a power hammer of suitable design to ensure the minimum of distortion to the rod. Where it is not possible to drive rods to the full depth required due to the presence of a strata of rock, then holes shall be drilled or blasted in the rock. The holes shall be filled with bentonite or other approved material prior to inserting the rod.

If difficult driving conditions arising from hard or rocky ground are encountered or are anticipated or there is a need for deep rods, then high tensile steel rods shall be used. High tensile steel rods shall have a molecularly bonded high conductivity copper coating with a minimum radial thickness of not less than 0.25 mm. The overall diameter shall be not less than 12 mm. Rolled external screw threads shall be used on the rods for coupling and after rolling the thickness of the copper coating on the threaded portion shall be not less than 0.05 mm.

Rods, driving caps and tips shall abut at couplings to ensure that the couplings and screw threads are not subject to driving forces. All screw threads shall be fully shrouded at the couplings. Alternatively, conical couplings may be used to the approval of the Engineer.

High conductivity copper for earth rods shall have a minimum copper content (including silver) of 99.90% to ISO 1337, Cu-ETP or Cu-FRHS (BS 2894 Grade C101 or C102) for copper earth rods and to ISO 1337 Grade Cu-ETP (BS 28734 Grade C101) for the molecular bonded copper coating of steel rods.

The steel for copper-clad steel rods shall be low carbon steel with a tensile strength of not less than 570 N/mm^2 to ISO 630, Grade Fe 430A (BS 4360, Grade 43A) or better.

Couplings for copper rods shall be of 5% phosphor bronze (copper-tin-phosphorous) to ISO 427, CU Sn4 (BS 2874, Grade PB 102M) and for copper bonded steel rods of 3% silicon or 7% aluminum bronze to BS 2874, Grade CS 101 and BS 2871, Grade CA 102.

7.9.3 Fittings

Clips for supporting strip conductors not buried in the ground shall be of the direct contact type and clips for circular conductors shall be of the cable saddle type. The clips shall support the conductors clear of the structure.

Conductors shall be connected to earth rods by a bolted clamp to facilitate removal of the conductor for testing the rod.

Disconnecting links shall comprise a high conductivity copper link supported on two insulators mounted on a galvanised steel base for bolting to the supporting structure. The two conductors shall be in direct contact with the link and shall not be disturbed by the removal of the link. Links for mounting at ground level shall be mounted on bolts embedded in a concrete base.

Disconnecting links mounted at ground level and the connections at the earth rods shall be enclosed in concrete inspection pits, with concrete lids, installed flush with the ground level.

All conductor fittings shall be manufactured from high strength copper alloys with phosphor bronze nuts, bolts, washers and screws. Binary brass copper alloys will not be acceptable. All fittings shall be designed for the specific application and shall not be permanently deformed when correctly installed.

Sheathed conductor support fittings may be of silicon aluminium, 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.

7.9.4 Joints

Permanent joints shall be made by exothermic welding below ground, or crimping for above ground connections.

Detachable joints shall be bolted and stranded conductors at bolted joints shall be terminated in exothermically welded lugs or a crimped cable socket. The diameter of any holes drilled in strip conductors shall not be greater than half the width of the strip.

Connections to electrical equipment shall be detachable and made at the earthing studs or bolts provided on the equipment by the manufacturer. When an earthing point is not provided, the point and method of connection shall be agreed with the Engineer.

Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be either by direct exothermic welding or by bolting using a stud welded to the structure. Drilling of a structural member for a directly bolted connection shall only be carried out to the approval of the Engineer.

Bolted joints in metallic structures, including pipework and which do not provide direct metallic contact, shall either be bridged by a bonding conductor or both sides of the joint shall be separately bonded to earth, unless the joint is intended to be an insulated joint for cathodic protection or other purposes.

When the reinforcing in concrete is used as a part of the earthing system, the fittings used to provide a connection point at the surface of the concrete shall be exothermically welded to a reinforcing bar. This fitting shall be provided with a bolted connection for an earthing conductor. The main bars in the reinforcing shall be welded together at intervals to ensure electrical continuity throughout the reinforcing.

No connections shall be made to reinforcing bars and other steelwork which do not form part of the earthing system and are completely encased in concrete.

7.10 EARTHING OF FENCES

7.10.1 Method

Metallic fences shall be separately earthed unless they come within 1.8m of any equipment or structure above the surface of the ground and which is connected to the main earthing system. If the separation of 1.8m cannot be obtained, the fence shall be bonded to the main earthing system.

7.10.2 Separately Earthed Fences

The earthing of a fence shall be provided by connecting certain metallic fence posts to an earth rod by a copper conductor. The earth rod shall be driven adjacent to the posts inside the fence line to a depth of not less than 3.0m. Where no metallic posts are provided, the earth rods shall be connected directly to the metal wires, mesh or other components of the fence.

If, owing to the nature of the ground, it is not possible to drive earth rods, then fence posts shall be connected to the centre point of a 20 m length of bare copper conductor buried in the ground at a depth of 500 mm, running closely parallel to the inside of the fence.

The earth rods or bare conductor electrodes shall be installed at each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

7.10.3 Bonded Fences

Fences which need to be bonded to the main earthing system of the installation shall be connected by copper conductors to the nearest accessible point on the main earthing system at each point where the fence comes within 1.8 m of any electrical equipment. Bonds shall also be made to each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

7.10.4 Bonding of Fence Components

Fences made up of bolted steel or other metallic components do not require bonding between components. Where such fences have non-metallic components, bonds shall be installed to maintain continuity between metallic components. Reinforced concrete components shall be treated as being non-metallic.

Longitudinal wires for supporting other fence components, or for anti-climbing guards and the wires of chain link shall be directly bonded to each fence earth electrode or to each bond to the main earthing system.

Metallic components on masonry, brick, concrete or similar boundary wall shall be treated in the same manner as metallic fences.

Wire fence components coated for anti-corrosion protection shall be earthed in accordance with this Clause.

7.10.5 Gates

The fixed metallic components on both sides of the gate shall be directly bonded together by a copper conductor installed under the surface of the access way. Flexible conductors shall be installed to bond the moving parts of the gates to the metallic fixed parts. An earth rod or a bond to the main earthing system shall be installed at each gate.

7.10.6 Potential Control Outside Fences

Where the approved design calculations show that the touch or step potentials outside the fence or boundary wall would otherwise be excessive, bare copper conductors shall be buried in the ground outside the fence or boundary wall at such depths and spacings as are shown in the approved design calculations to give acceptable touch and step potentials. The conductors shall form complete rings surrounding the installation and each ring shall be bonded to the adjacent ring and to the fence at each corner, at each gate and at intervals of not more than 100 m. In this case separate earth electrodes are not required for the fences.

If the boundary fence or wall is substantially non-metallic, the rings of conductors shall be bonded to the main earth system at each corner of the site and at intervals of not more than 100 m. Any metallic components on such boundary fences or walls shall be bonded to the earthing system in accordance with this Specification.

If the boundary fence is metallic and is not within 1.8 m of any part of the main earthing system or equipment bonded thereto, the fence and outer conductor rings shall not be connected to the main earthing system unless the approved design calculations show otherwise.

Any meshes formed by bonding the outer conductors to the main earthing system shall be sub-divided by additional conductors, if required, to give acceptable touch, step and mesh potentials.

7.10.7 Conductors

All conductors used for earthing and bonding the fences and components and for outer rings shall have a cross-sectional area of not less than 75 mm^2.

SECTION 8

BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

TABLE OF CLAUSES

SECTION 8

BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

8.1 SCOPE

These clauses describe the General Technical Requirements for Batteries, Chargers and DC distribution switchgear for use in substations for 110V DC power for switchgear operations, protection, control, alarms, indications and emergency lighting.

The equipment shall be supplied, installed and commissioned as per instruction and approval of the engineers.

8.2 REFERENCES

8.2.1 IEC Standards

IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
IEC 60146	Semiconductor converters
IEC 60146-1-1	Basic requirements of electrical power converters
IEC 60146-1-3	Transformers and reactors
IEC 6060529	Degree of protection provided by enclosures
IEC 60439	Low voltage switchgear and control gear assemblies (BS EN 60439)
IEC 60623	Vented nickel cadmium prismatic rechargeable single cells

8.2.2 British Standards

BS 88	Cartridge fuses for voltages up to and including 1000 VAC and 1500 V DC.
BS 381C	Specification for colours for identification coding and special purposes.
BS 5634	Method of Test for Potassium Hydroxide.
BS 6231	Specification for PVC insulated cables for switchgear and controlgear wiring.

8.3 DESIGN REQUIREMENTS

8.3.1 General

Batteries shall be located in separate mechanically ventilated rooms, which will be provided with sinks and water supplies. Storage facilities will be provided for electrolyte, distilled water and maintenance equipment.

The voltage measured at the main distribution switchgear shall not vary by more than plus 10 percent or minus 20 percent of the nominal voltage under all charging conditions when operating in accordance with the requirements of this Section.

The complete equipment shall preferably be a manufacturer's standard but any departure from this Specification shall be subject to the approval of the Engineer.

8.4 BATTERIES

8.4.1 Type of Battery

The battery shall be of the high performance Nickel Cadmium pocket plate type complying with IEC 60623 and shall be designed for a life expectancy of 25 years.

Battery cases shall be of high impact translucent plastic or annealed glass and shall be indelibly marked with maximum and minimum electrolyte levels. The design of the battery shall permit the free discharge of the gases produced during the normal operating cycle, whilst excluding dust. Spray arresters shall be included.

The electrolyte shall be free from impurities and the Potassium Hydroxide used shall comply with BS 5634. Dilution of the alkaline electrolyte and topping up of cells shall be carried out using distilled water only.

A complete set of test and maintenance accessories, suitably boxed, shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Cells shall be permanently marked with the following information:

- Manufacturer's reference number and code
- Year and month of manufacture
- Voltage and nominal capacity at the 5 hour discharge rate

The electrolyte capacity and general design of the cells shall be such that inspection and maintenance, including topping up of the electrolyte, shall be at intervals of not less than twelve months.

8.4.2 Initial Charge and Test Discharge

The initial charge, test discharge and subsequent re-charge of the battery must be carried out under continuous supervision. Resistors, instruments, leads, and the other apparatus will be necessary for the initial charge, test discharge and subsequent recharge of the battery.

8.4.3 Battery Duty

The battery shall have sufficient capacity to supply the following continuous and intermittent loads for the periods specified, with the chargers out of service.

Standing DC loading for protection, control, indications and alarms for 10 hours. This loading shall be determined from all equipment to be supplied on this Contract. In addition the future circuit requirements estimated on the same basis as the present requirements.

At the end of 5 hours the battery shall have sufficient capacity to complete the operations listed below, at the end of which duty the system voltage shall not have dropped below 90 percent of the nominal voltage with the standing loads, specified above, connected.

1. Two closing operations on all circuit breakers (including future) supplied by the battery.

2. Two tripping operations on all circuit breakers (including future) supplied by the battery. Where busbar protection is provided, it shall be assumed that all circuit breakers in any one busbar protection zone trip simultaneously.

3. Charging of DC motor wound circuit breaker closing springs (where applicable) to enable the closing operations to be carried out.

4. At the end of these duties, the battery voltage shall not have dropped such that the voltage at the battery terminals falls below 90% of the nominal system voltage when supplying the standing load.

5. In addition, the voltages at the terminals of all components in the system (eg. relays, trip and closing coils) shall not be outside of the individual voltage limits applying to them.

6. A margin of 10 % shall be allowed for derating of this battery over its life time.

All quantities derived in this manner shall be quoted in the Tender, but shall not be used for ordering materials until specifically approved by the Engineer. Detailed calculations, and loading characteristics on which these are based, shall be submitted to the Engineer at an early stage.

8.4.4 Location of Batteries

The batteries shall be housed in a ventilated battery room. The charging equipment and distribution switchboards shall be housed in a separate room.

The floor of the battery room shall be coated with a suitable electrolyte resistant protective coating. The floor shall be fitted with a drain and shall have sufficient slope to prevent any major electrolyte spillages from entering into other areas.

No ducts or any other items shall penetrate the floor or create a means whereby spillage can drain away apart from the drain provided for this purpose.

The ventilation fans and lamps in battery room shall be an explosion proof type.

8.4.5 Battery mounting connections and accessories

Batteries shall be placed on timber boards mounted in double tiers on steel stands of robust construction and treated with acid resisting enamel or gloss paint to BS 381C No.361. The cells shall be arranged so that each cell is readily accessible for inspection and maintenance and it shall be possible to remove any one cell without disturbing the remaining cells. The stands shall be mounted on insulators and be so dimensioned that the bottom of the lower tier is not less than 300mm above the floor.

Alternatively, batteries may be mounted in a similar manner on treated hardwood stands.

Batteries shall be supplied and erected complete with all necessary connections and cabling. Connections between tiers, between end cells and between porcelain wall bushings shall be by PVC cables arranged on suitable racking or supports. Before jointing, joint faces shall be bright metal, free from dirt, and shall be protected by a coating of petroleum jelly. Terminal and intercell connections shall be of high conductivity corrosion free material.

Cartridge fuses shall be provided in both positive and negative leads, positioned as close to the battery as possible and shall be rated for at least three times the maximum battery discharge current at the highest operating voltage. The two fuses shall be mounted on opposite ends of the battery stand or rack in an approved manner. These fuse links shall comply with BS 88 Clause DC. 40 and shall be bolted in position without carriers.

Warning labels shall be fitted to warn personnel of the danger of removing or replacing a fuse whilst the load is connected and that fuses should not be removed immediately following boost charge due to the possible ignition of hydrogen gas.

Fuses between the battery and charger shall be located adjacent to the battery in a similar manner to that described above. A warning label shall be placed on the charging equipment indicating the location of these fuses and the fact that they should be removed to isolate the charger from the battery.

It shall not be possible to leave the battery disconnected (by means of switches or removal or operation of fuses) without some local and remote indication that such a state exists.

One set of miscellaneous equipment, including two syringe hydrometers, one cell-testing vol tmeter, two cell-bridging connectors, two electrolyte-pouring funnels, two electrolyte thermo meters, battery instruction card for wall mounting, electrolyte airtight containers, labels, tools and other items necessary for the erection and correct functioning and maintenance of the equipment, shall be provided for each station.

8.5 CONTROL AND CHARGING EQUIPMENT

Each battery charging equipment shall comply with the requirements of BS 4417 (IEC 146), shall be of the thyristor controlled automatic constant voltage type with current limit facilities and shall be suitable for supplying the normal constant load, at the same time maintaining the battery to which it is connected in a fully charged condition. All equipment shall be naturally ventilated.

All the equipment for each charger shall be contained in a separate ventilated steel cubicle. The charger cubicles shall normally be mounted immediately adjacent to the DC distribution panel to form a board and shall be of matching design colour and appearance.

Where their ratings permit, chargers shall preferably be designed for operation from a single-phase AC auxiliary supply with a nominal voltage of 230 V. Otherwise a three phase 400V supply may be utilised. Chargers shall maintain the float charge automatically for all DC loads between 0 and 100%, irrespective of variations in the voltage of the ac supply within the following limits :

- Frequency variation : 47 to 51 Hz.
- Voltage variation : ± 15%

The mains transformer shall be of a suitable rating and design. Clearly marked off-circuit tappings shall be provided on the primary windings and change of tapping shall be by means of easily accessible links. The transformer shall be of the natural air-cooled type capable of operating continuously at full load on any tapping with the maximum specified ambient temperature.

All rectifiers and semi-conducting devices employed in the charger shall be of the silicon type. They shall be adequately rated, with due regard to air temperature within the charger enclosure, for the maximum ambient temperature.

The rating of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate for the battery.

Each charger shall also incorporate a boost charge feature which shall, after having been started, provide an automatically controlled high charge rate sufficient to restore a fully discharged battery to the fully charged state within the shortest possible time without excessive gassing or any form of damage to the battery. The boost charge shall be initiated manually or automatically upon detection of a significant battery discharge. An adjustable timer shall be provided to automatically switch the charger to the float condition after the correct recharge period. Load shall be kept connected to the charger during boast charge.

Should the AC supply fail while a battery is on boost charge, the switching arrangements shall automatically revert the charger to float charge status and then reconnect the battery to the distribution board.

The output voltage regulator shall be adjustable for both float and boost charge modes, within limits approved by the Engineer, by means of clearly marked controls located inside the cubicle.

Although it is not intended that the charger be operated with the battery disconnected, the design of the charger shall be such that with the battery disconnected the charger will maintain the system voltage without any damage to itself and with a ripple voltage no greater than 2.0% rms of the nominal output voltage.

The charger shall automatically adjust the charging current from Boost to float charging current when required. The charging circuitry shall be so designed that the failure of any component will not give a situation which will cause permanent damage to the battery by over charging.

Each charger shall have a float charge maximum current rating sufficient to meet the total standing load current on the dc distribution board plus a battery charging current equal numerically to 7% of the battery capacity at the 10 hour rate.

Each charger shall be designed with a performance on float charge such that with the output voltage set at approximately 1.45 V per cell at 50% load and rated input voltage and frequency, the output voltage shall not vary by more than plus 3% to minus 2% with any combination of input supply voltage and frequency variation as stipulated in this Specification and output current variation from 0-100% of rating.

Each charger shall be suitable for operating alone or in parallel with the other charger. When operating with both chargers, one charger shall be arranged to supply the standing load with the second charger in the quiescent standby mode.

Each charger shall also have a taper characteristic boost charging facility which shall be selectable by a float/boost charge selection switch and which will give boost charging of 1.60 - 1.75 volts per cell.

Each charger shall be designed with a performance on boost charge such that with rated input voltage and frequency the charger output shall not be less than its rating in Watts at 1.3 V and 1.65 V per cell, and also the output voltage shall be 1.60 - 1.75 V per cell over an output range of 0 - 100% of rating.

The boost charging equipment shall be capable of recharging the battery within six hours following a one hour discharge period.

In the event of the battery becoming discharged during an AC supply failure, the rate at which recharging commences shall be as high as possible consistent with maintaining the automatic charging constant voltage feature and with the connections remaining undisturbed as for normal service.

The charger shall have an automatic boost/quick charge feature, which shall operate upon detection of a significant battery discharge. When, after a mains failure, the AC supply voltage returns and the battery have been significantly discharged, the charger will operate in current limit. If the current limit lasts for more than a specified time and the charging current does not fall back to float level, the automatic high rate charge shall be activated.

An override selector switch shall be provided inside the charger unit to enable a first conditioning charge to be made, in line with the battery manufacturer's recommendations, for batteries which are shipped dry and require forming at site.

A diode voltage regulator(DVR) unit shall be incorporated in the output circuit of each charger to limit the load voltage during charging of the battery. These diodes shall be continuously rated to carry the maximum possible load current during boost charging. The diode unit shall not be in service in the normal float charging mode. Should the voltage stabilizer/ DVR unit fail in the boost charging mode, the charger shall automatically revert to the float mode.

An anti-parallelling diode shall be provided in each positive feed to the DC distribution board to prevent faults on one supply affecting the other. These diodes shall be continuously rated to carry the maximum possible discharge current likely to occur in service and a safety factor of 4 shall be used to determine the repetitive peak reverse voltage rating. The I2t rating of the diodes shall be such that in the event of a DC short circuit, no damage to the diodes shall result.

Each charger shall be capable of sustaining, without damage to itself, a continuous permanent short circuit across its output terminals. The use of fuses, MCBs or other similar devices will not be acceptable in meeting this requirement.

Suitable relays shall be provided for each charger to detect failure of the incoming supply and failure of the DC output when in float charge mode. These relays shall operate appropriate LED on the respective charger front panel and shall have additional voltage free contacts for operating remote and supervisory alarms. These alarms shall be immune from normal supply fluctuations and shall not be initiated when any one charger is taken out of service.

The charger shall also be fitted with a device to de-energise the charger in the event of a DC output float over voltage.

Each charger shall be provided, as a minimum, with the following instrumentation, indication and alarm facilities:-

- Indicating lamps for the AC supply to the rectifier and DC supply from the rectifier.
- Indicating lamps for float and boost charging operations.
- Voltmeter - Input voltage.
- Voltmeter - Output voltage.
- Ammeter - Output current.
- Alarm - Charger failure.
- Alarm – Charger Main transformer failure.
- Alarm – Charger Rectifier Diode Module failure.
- Alarm – Charger DVR module failure.
- Alarm - Mains failure.

The following battery alarms shall also be provided:

- Battery fuse failure
- Diode assembly failure
- Battery circuit faulty
- Low DC volts
- High AC volts
- Earth fault +ve
- Earth fault -ve

Lamp test facilities shall be included.

A “charger faulty” alarm for each charger and a “battery faulty” alarm shall be provided in the substation control room and to the SCADA system where applicable.

Each battery charger shall be equipped with charge fail detection equipment to give local indication and remote alarm if the voltage from the charger falls below a preset level which will be lower than the nominal float charge voltage. Suitable blocking diodes shall be provided to prevent the battery voltage being supplied to the equipment and so prevent charge fail detection.

The device shall not operate on switching surges or transient loss of voltage due to faults on the AC system. The voltage at which the alarm operates shall be adjustable for operation over a range to be approved by the Engineer.

Each charger shall be equipped with a switch-fuse for the incoming AC supply and an off load isolator for the DC output.

Bidders shall include particulars with their tender on the method of adjustment included to compensate for ageing rectifier elements. The construction of the charger shall be such that access to all components is readily available for maintenance removal or replacement. Internal panels used for mounting equipment shall be on swing frames to allow for access to the charger interior.

A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the charger panel.

A low voltage detecting device for the system shall be incorporated in the charger panel. No-volt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.

In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

8.6 DISTRIBUTION SWITCHBOARDS

The switchboard shall comply with the requirements of BS 5468 (IEC 60439)

The distribution switchboard shall be of the cubicle type or otherwise incorporated in the cubicles for battery chargers. Double pole switches and fuses or switch fuses (miniature circuit breakers to BS 4752 or IEC 60127 may only be used if it can be shown that there will be no discrimination problems with sub-circuits) shall be fitted to the DC switchboard as required by substation services but, as a minimum requirement, that set out in the Schedule A of Requirements.

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of cubicle type control panels. No equipment associated with the chargers shall be installed in the distribution board.

Distribution panels shall incorporate double-pole switches and fuses for each of the outgoing DC circuits and double-pole isolators for the incoming DC supplies. The panel shall be provided with a voltmeter and centre zero ammeter on each incoming circuit.

A switching device, MCB/MCCB or contactor shall be provided for the purpose of sectionalising the busbar.
A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the distribution panel.

A low voltage detecting device for the system shall be incorporated in the distribution panel. No-volt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.

In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage detecting devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

Connections between the battery and the distribution cubicle shall be made in PVC insulated cable as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring, be sheathed overall and be cleated to walls as required.

Cable boxes or glands shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with an earthing bar of hard drawn high conductivity copper which shall be sized to carry the prospective earth fault current without damage or danger.

The cubicles for the chargers and distribution boards shall be of rigid, formed sheet metal construction, insect and vermin proof, having front facing doors allowing maximum access to the working parts, when open. The design of the cubicles for the chargers shall be such as to prevent the ingress of dust and minimise the spread of flames or ionised zones, shall be to IEC 60529 IP52, but at the same time shall provide all necessary ventilation and cooling. The design of the frames shall allow the clamping and holding of all chokes, transformers and similar sources of vibration, so that vibration will be minimised, satisfy relevant standards, and not limit the life of the equipment. The frame shall allow the fixing of lifting and so that the equipment remains properly mechanically supported whilst being transported, lifted and installed.

8.7 LABELLING

All relays, instruments and control devices, and each unit of the equipment, shall be provided with a label. All labels and lettering shall be of sufficient size to provide easy reading from the normal operating or maintenance positions and shall consist of black lettering on a white background. All warning and danger labels shall have white lettering on a red background. Labels shall be of the non-corrodible type and lettering shall be of motorway script or similar. If plastic labels are used, these shall be laminated to avoid warping.

8.8 SPECIAL TOOLS

The Contractor shall provide a complete set of all special tools and services necessary for the erection and maintenance of the complete equipment.

8.9 INSPECTION AND TESTING

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

SECTION 9

LV AC DISTRIBUTION SWITCHGEAR

TABLE OF CLAUSES

SECTION 9

LVAC DISTRIBUTION SWITCHGEAR

9.1 SCOPE

These clauses describe the General Technical Requirements for LVAC switchboards for supplies to “Substation Services” including lighting and control building services (Section 10).

9.2 REFERENCES

IEC 60044	Instrument Transformers		
IEC 60269	Low Voltage Fuses		
IEC 60439-1	Specification for low voltage switchgear and control gear assemblies		
IEC 60644	Specification for high-voltage fuse links for motor circuit applications		
IEC 60898	Electrical Accessories - Circuit-breakers for overcurrent protection for household and similar installations		
IEC 60947-1	Low-voltage switchgear and Control Gear	-	General
IEC 60947-2	Low-voltage switchgear and Control Gear	-	Circuit-breakers
IEC 60947-3	Low-voltage switchgear and Control Gear	-	Switches, disconnectors and fuse combination units
IEC 60947-4	Low-voltage switchgear and Control Gear	-	Electromechanical Contactors and motor starters

9.3 SWITCHBOARD DESIGN

9.3.1 General

Main switchboards and MCB sub-distribution boards for substation and building supplies will be constructed to IEC 439, (BS EN 60439) in accordance with the following:

The classification of the main switchboards shall be:

(a) The external design of switchboards shall be of the multi-tier, multi-cubicle type.

(b) Installation shall be indoors.

(c) Switchboards shall be free standing and fixed to the floor.

(d) Enclosures degree of protection shall be not less than IP42.

(e) Switchboards shall be of metal clad construction.

(f) All instrumentation and metering shall be fixed to a hinged lockable compartment.

(g) Switchboards and all associated equipment shall be suitable for use on a 400/230 volt, three phase, four wires, and 50 Hz system having the neutral solidly earthed.

(h) Each circuit shall be clearly labelled to show the destination of the associated cable and the “ON” and “OFF” positions of the switches.

(i) Distribution boards for exterior use shall be galvanised, weatherproof and to category IP55 degree of protection.

The equipment shall be of the single busbar type with circuit equipment housed in separate compartments.

Where two or more incoming circuit breakers are provided at substations, these shall be mechanically and electrically interlocked to prevent more than one circuit closing at the same time.

The enclosures of all switchboards shall be dustproof and vermin proof. Access doors shall be mounted using concealed hinges. All removable covers shall be fitted with captive screws. Anti-condensation heaters with control switches shall be provided on switchboards. They shall be suitable for a tropical climate.

9.3.2 Rating

Incoming supplies to all switchboards shall be protected at the point of supply. All switchboards shall be suitably rated for a prospective short-circuit breaking capacity of 15 kA at 400V for three seconds.

9.3.3 Busbars

Busbars shall be capable of carrying the full rated current continuously without exceeding the maximum temperature specified in IEC 60439 under site ambient conditions.

Busbars shall be of copper, individually covered with a heat resistant phase coloured PVC. Busbar links between panels shall not be used. Neutral busbars shall have the same cross sectional areas as the phase busbars. Busbars shall be of the same current rating throughout their length and shall be capable of extension at both ends with the minimum disturbance to the busbar and cubicle enclosure.

9.3.4 Busbar and Circuit Shutters

For drawout equipment shutters shall be provided over busbar and circuit orifices to close automatically and positively when the equipment is isolated or withdrawn. Means shall be provided for padlocking the sets of shutters. Busbar orifice shutters shall be painted signal red and labelled ‘BUSBAR’ in white letters. Circuit orifice shutters shall be painted lemon yellow.

One blanking cover of each size shall be provided to prevent access to a circuit compartment when the equipment has been completely withdrawn from the panel.

9.3.5 Circuit Labels

Approved type title labels are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit list shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit list, the list and cover to be easily removable to permit circuit modifications.

9.4 CIRCUIT BREAKERS

All MCB and MCCB circuit breakers shall be high speed fault limiting, thermal/magnetic type with quick break, trip free mechanisms which prevent the breaker being held in against overloads or faults, shall comply with IEC 60947 and be fitted with overcurrent releases of both thermal and instantaneous type. Short circuit performance shall be to IEC 60947.

Where circuit breakers incorporate thermal overload protection and short-circuit protection, their settings shall be subject to agreement with the Engineer.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionising arc chutes.

Circuit breakers on the incoming circuits shall have facilities for locking in the “off” position.

The fault interrupting capacity of the circuit breaker shall not be less than that of the switchboard itself, or if this is not the case, back up fuses shall be included.

9.5 SWITCH-FUSES

Each switch-fuse unit shall be housed in a separate metal compartment and provided with a hinged metal door, interlocked with the switch mechanism so that:

(a) The door cannot be opened whilst the switch is closed.

(b) The door, on opening, automatically locks the switch in the “off” position. Facilities shall be incorporated to allow for the deliberate release of this interlock for maintenance purposes, should it be desired to observe the switch in operation.

An insulating barrier shall be fitted to segregate the fuses and neutral link from the switch and the connections of the latter shall be effectively shielded by an inner metal screen when the compartment door has been opened to obtain access to the fuses.

The switch-fuses may be either of the combination fuse-switch type or of the type with the switch and fuse in separate units. In either case, interlocking shall be provided to prevent access to the fuses until the associated switch is opened and provision shall be made for padlocking the switch in the “on” and “off” positions.

The switch shall have a quick make and quick break action, independent of the speed at which the switch handle is operated, and shall be entirely suitable for switching the inductive loads associated with motor circuits.

9.6 OIL FILTRATION SOCKET OUTLET AND PLUG

The Contract shall include heavy duty weatherproof three phase and neutral interlocked switched socket outlets and plugs suitable for supplying the transformer oil filtration units.

9.7 INSPECTION AND TESTING

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

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT
FOR

Design, Supply, Installa-tion, Testing and Commissioning of 230 KV In-door GIS Substation with 132 kV AIS at Faridpur, and Bay Extension of existing 230/132 kV Barisal (North) AIS Substation on turnkey basis

SECTION 10A
BUILDINGS AND CIVIL ENGINEERING WORKS (FOR OUTDOOR GIS AND AIS)

SECTION 10 A

BUILDINGS AND CIVIL ENGINEERING WORKS (FOR OUTDOOR GIS AND AIS)

TABLE OF CLAUSES

SECTION 10 A

BUILDINGS AND CIVIL ENGINEERING WORKS (FOR AIS)

10A.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.

10A.1.1 Scope of Work

The work includes the design, detailing, construction and maintenance of the following:

(i) performance of site survey and subsoil investigation

(ii) site preparation including cutting or filling up to the level specified in 10A.1.4 and levelling as well as compaction.

(iii) foundations for all equipment to be installed in outdoor switchyards.

(iv) road including access road and roadways within sites, surfacing the entire area within site boundary and surface water drainage.

(v) cable trenches, cable tunnels, cable ducts and pipe ducts

Included in the scope of work is the detailing, construction and maintenance of the following items which shall generally be constructed to the Employer's standards but full working drawings shall be prepared by the Bidder:

(a) water supply tubewell and plumbing installations

(b) surface water, foul and storm drainage

(c) lighting, small power, external floodlighting, emergency lighting and fire protection

10A.1.2 Bidder to satisfy himself as to all conditions

The Bidder shall assess:

(i) access conditions at site, plus ground condition and ground bearing capacity

(ii) transport costs, materials costs and restrictions of availability of supply of materials locally

(iii) importation restrictions and delay due to customs controls

(iv) restrictions imposed by existing equipment on sequence of construction, access, etc.

(v) restrictions caused by cable laying and overhead line Bidders

(vi) ground conditions and temporary works required to provide support during excavation

10A.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.

10A.1.4 Site Survey Drawings

The Bidder shall prepare a survey at 1:200 scale showing existing ground levels on a maximum 10 metre grid and details of all features above and below the ground within the site boundary and up to 15 metres 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 of the site will be 500mm above the crown of the nearest public road or the highest flood level whichever is greater. The building plinth level will be 450mm above the final ground/formation level.

10A.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.

10A.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, 1 executive chair, 2 visitor chairs, 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.

10A.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.

10A.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 6 weeks before the key dates to allow for the Engineer to comment and his comments to be incorporated in the drawings:

1. Issue of approved site survey drawing complete with soil levels and floor levels
2. Issue of approved electrical layout drawings
3. Completion of Site Investigation field work
4. Issue of approved Site Investigation Final report
5. Completion of loading tests on a foundation on fill site and any other site where settlement is likely to be a problem
6. Issue of approved drawings required for Planning Permission
7. Issue of a full complete set of civil building drawings
8. Construction start date
9. Date access will be given for:
   - i) Installation of equipment in Buildings
   - ii) Installation of outdoor plant
10. Construction finish date

The drawing programme shall ensure that complete set of approved civil building drawings will be issued at least 21 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.

10A.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.

10A.1.9 Temporary Facilities

The Bidder shall provide all temporary buildings, workshops, 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.

10A.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 two days before the work starts for the activities as described below:

i) subsoil investigation

ii) every concrete pour and foundation casting

10A.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) 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 of drawings 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.

10A.2 REFERENCES

10A.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 10A.2.2 below.

10A.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 1 Code 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

10A.3 DESIGN

10A.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.

All buildings 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.

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 cast iron 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 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 0.8 metre high with an insitu concrete coping 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 (Mirpur ceramics or similar approved) to ensure good air circulation over the roof. 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 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 Mirpur Ceramics or similar approved facing bricks. External walls of other buildings shall be minimum 230mm first class brickwork plus one layer of Mirpur Ceramics or similar 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 height of ground floor of two storey control building shall be 3.0 metre and the minimum minimum height of first floor control room shall be 4.0 metre. False ceiling should be provided in the control room floor. In the switchgear rooms, minimum 1 metre 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 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, 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.

10A.3.2 Ground Conditions, Foundations and Site Investigation

(a) Fill Sites

The Bidder shall impose the site layout on the survey to check for uneven depth of fill below any foundation and where uneven depth of fill exists his foundation proposals shall restrict final differential settlement to a 1 in 400 slope.

If a fill site has not been exposed to one wet season before foundation work starts, the Bidder shall flood the site to a depth of 50mm for 10 days (Not required on hydraulic fill sites). This requirement is because silty sands will generally compact to a denser condition on first time flooding.

On all fill sites the Bidder shall pipe rainwater from down pipes down to paddy level and shall prevent water ponding in open foundations and backfill all foundations as soon as possible.

When a filled site is handed over to the Bidder, the Bidder shall become responsible for maintaining the entirety of the fill in good condition, including all better slopes.

(b) Unfilled Sites

Original delta levels are generally below road level. Therefore most sites are historically fill sites but fill settlement can sensibly be considered complete, where fill is over 3 years old.

(c) Site Investigation

Detailed methodology for subsoil investigation shall be submitted before implementing the subsoil investigation. All laboratory tests shall be done at the test facility approved by the Employer.

The Bidder may appoint a sub Bidder to carry out the site investigation but all work and all lab work shall be witnessed by one of his Geo-technical engineer who shall countersign all recorded data.

1 borehole should be counted for every 600 square meter of proposed project area and provided on suitable points. At least three additional boreholes should be provided for

control building and switchyard panel room building or any other building. For boundary wall/retaining wall additional boreholes shall be provided on in each corner point and at a maximum 50m interval point. Additional boreholes may also be required where uneven fill depth is encountered. The number and location of boreholes shall be approved with the site survey drawing showing existing ground levels specified in the section 10A.1.4. The boreholes shall be located to an accuracy of $\pm$ 0.5m and shall be located to site layout considering existing obstacles at the field.

Boreholes shall be a minimum of 25 metres depth or twice building footing width, 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 2.0 metres, 3.0 metres depth for unfilled site; 2.0 metres, 3.0 meters, 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 each depth. The samples shall be saturated and the range of applied pressure shall fully reflect the insitu 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. Where collapse of the boreholes occurs, casing shall be used and left in until the water level remains constant for two days.
- In cohesive soils a vane test to BS 1377: Part 9 shall be carried out at three different depths. The Bidder shall check the sensitivity of soil and ground water at each site to concrete and take all measures necessary to ensure the long term durability of concrete.

The Bidder shall give the Engineer the requisite period of notice prior to commencing the geotechnical investigation at the field. The field sheets of each bore log shall be signed by the geo-technical engineer of Bidder and representative of the Engineer. The signed field sheets shall be include in site investigation report.

(d) Site Investigation Report

The site investigation and analysis of the data in a final report giving full details of foundation proposals shall be completed at each site by the programmed date. During site investigation, Geographical map shall be prepared indicating the locations of soil test.

The report shall be submitted by the key date at each site given in the programme. The Bidder shall submit 3 copies of the report to the Engineer. The report shall propose full details of foundations and loading thereon and shall provide estimates of likely settlements and differential settlements. The report shall be the work of the Bidder's own foundation engineers.

If the Bidder uses a local site investigation Bidder, he shall appoint one of his geo-technical engineer to oversee the entire operation and each piece of data shall be countersigned by this person.

Where estimated settlement exceeds 25mm, the Bidder shall construct one foundation at an early stage and test load this foundation to confirm settlement predictions.

(e) Foundations

Regardless of the result of soil investigation report, the foundations of control building, boundary wall, gantry structures and for auto-transformers shall be provided with piles. Piles shall be concrete (cast-in-situ or precast) complying with BS 8004.

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 70mm minimum thickness of Class B concrete blinding, within 24 hours of bottoming excavation, which blinding shall project 300mm minimum distance beyond all footings. Each footing shall be inspected by the Engineer. Where soil condition is poor (on fill sites or already filled sites) or where the Bidder leaves foundations exposed and soil conditions deteriorate, one of the following measures shall be carried out as agreed with the Engineer:

i) Blinding depth and projection shall be increased as necessary.
ii) Soft soil shall be removed and replaced with compacted viti 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. In addition column footings shall be tied at foundation level and also floor level by beams to every adjacent column in both orthogonal directions.

These beams shall be designed to resist 1 in 200 differential settlement without distress and shall be capable of resisting the earthquake load of 0.1G.

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 two 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.

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.

One working pile of control building and one of auto-transformers at each site shall be load (compression) tested to 150% of design load in accordance with BS 8004. One working pile of gantry foundation at each site shall be load (uplift) tested to 100% of design load in accordance with BS 8004.

10A.3.3 Drainage

The entire surface within boundary walls shall be of uniform sloping site, sloping at 1 in 300 minimum slope to open channels around the entire perimeter. These channels shall be designed for a rainfall intensity of 60 mm 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 70mm. 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 10A.3.16.

The cable trenches will thus form barriers to surface water drainage. If the cut off area exceeds 30m^2 it shall be drained by a 200mm minimum diameter concrete 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 700mm. 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 600mm. x 600mm clear openings and airtight 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 80. 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, non 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.

Main control building shall be provided with a septic tank designed for 10 users and a soakaway of open brick construction 11m deep by 2.2m diameter filled with broken bricks. The septic tank shall be located at least 15 metres from buildings. 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. Two vents of minimum height 2.2m shall be provided on each septic tank.

If a town's water supply is unreliable, the roof rain water shall be collected in an underground tank of standard Employer's design.

10A.3.4 Surfacing

For the whole of the switchyard outdoor equipment area the ground shall be surfaced with gravel or other readily available local stone as approved by the Engineer. The switchyard surfacing shall be clean, thoroughly washed when necessary, and free from clay, soil or contaminating material and shall be graded from 20 - 45mm, laid and lightly compacted to a finished thickness of 175mm. Below the gravel 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.

The substation plot, outside of the designated switchgear equipment areas, shall be turfed. Turf shall be of good quality, free from weeds and shall be a minimum of 40mm thick. 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 vegetable soil, 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.

10A.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 15 cm thickness fitted with construction joints at distances not exceeding 6.0 m. 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 assess all practical requirements like culvert construction, removal of any obstacles, permission from local authorities etc. for access road. All necessary works shall be the bidder's responsibilities.

The width of access road from outside the site boundary to connect to any adjacent public road shall be 6 meters. All roads within the site boundary shall be generally 6 metres wide between the outer edges of kerbs for main road and 4.5 meter & 3 meters wide for sub road.

The road edge shall be formed by Class B concrete kerb 300mm wide by 250mm deep, placed over one layer of bricks laid flat. The road shall be a Class A concrete slab of average 150mm deep at each edge with 1:50 cross fall and stiff broom concrete finish reinforced with 8mm bars at 125mm centres longitudinally and 8mm bars at 125mm centres transversely placed 60mm below the upper surface. Expansion and contraction joins shall be detailed on site plans. Expansion joints shall have oil resisting grade polysulphide 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.

10A.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 tubewell 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 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 galvanised steel 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.

10A.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 300mm 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 10 gallon 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.

10A.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 sandThe 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 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 minimum 100mm 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.

Each 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 room shall 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.

10A.3.9 Cable Basement

Not used.

10A.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.

10A.3.11 Control Room Floors

No raised floor shall be used.

10A.3.12 Site Clearance, Obstructions and Adjacent Structures

The Bidder shall be responsible for clearance of:

(1) Trees, shrubs and any vegetation including the extraction of all roots and compaction of backfill where roots have been extracted.

(2) The removal of all buildings, sheds or any other structures above or below ground including the removal of any septic tanks, drains or other underground services.

(3) The removal of any existing surfacing, roads, foundations or any other obstruction.

All material cleared away by the Bidder shall be the property of the Employer and shall be removed by the Bidder to a site in the Project area upon instructions of the Employer. The Employer may remove any buildings or structures himself from sites before the commencement of site works.

Where an existing service, existing equipment or adjacent building is to be retained, the Bidder shall take all necessary measures to protect the item concerned from damage and shall be responsible for ensuring that no movement of foundations occurs during or after completion of construction.

Any existing electrical equipment/cables which have to be modified or repositioned shall be included in the works at no extra cost. Any buried gas or water main services which require to be diverted shall be deviated by the Employer at his cost. However, where it is possible to retain these existing services and build new structures around them, the Bidder shall take all necessary measures to build in the service at no extra cost.

10A.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 Bidder 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 Bidder shall erect a permanent fence 2.0m high in accordance with BS 1722 part 10 or similar approved.

10A.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 below 2.5 metres 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 500mm 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.

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.

10A.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 2500mm. 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 door leaf shall have minimum three 150mm heavy iron hinges equally spaced. 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 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.

10A.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 of Mortar designation (iii), 1: 1: 5 to 6. Cement, lime, sand.

All brick panels shall be tied to the concrete frame with galvanised ties of approved design. Ties shall be painted with bituminous paint.

Facing bricks shall be approved quality and size from Mirpur ceramics or similar approved. 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 with maximum variation of 0.75m. 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, two 6mm. bars per course extending 900mm beyond the opening both sides where possible.

All exposed brickwork shall be rendered and painted where not faced with facing bricks.

10A.3.17 Expansion Joints, Joint Fillers and Sealants

Not used.

10A.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 below the trench at low points; 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 downstand 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 buildup. 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.

10A.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.

10A.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:

i) a small open channel conveying the water to the boundary channel

ii) a pipeline conveying the water off the site. Rainwater shall not be connected to the septic tank or allowed to discharge directly onto switchyard paving.

10A.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 weatherproofer 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.

10A.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.

Carriage way is required to be provided with rail connected to all transformer bases. Transformer shall be anchored in such a manner so that it can prevent the movement of transformer for 0.2G ground acceleration.

10A.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. 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 same 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.

10A.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 two 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, including all brick ties, 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.

10A.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.

10A.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
Min Cement Content	360kg/m^3	170kg/m^3
Max Water Cement ratio	0.55	-
Coarse Aggregate type	Broken stone	Jhama brick
Max Coarse aggregate size	20mm (40mm for piling)	25mm
Method of Batching	Volume batching	Volume batching
Min Characteristic of Trial Mix at 28 days	30N/mm^2	
Min characteristic strength of trial mix at 7 days	14N/mm^2	-
Min characteristic strength of works cubes at 28 days	20N/mm^2	-
Slump Range		
Slump for concrete placed	30mm min-100mm max	
below water in piling	150mm min	

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 20N/mm^2. Design shall be in accordance with this Contract and BS 8110 or other agreed standard.

Minimum cover to rebars shall be 60mm where concrete is in contact with backfilled soil against a shuttered face, 100mm where concrete is cast against soil, and 30mm 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. 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.

10A.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 6mm 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.

10A.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.

10A.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.

10A.3.30 Lifting Beams (Not required for this contract)

Deleted.

10A.3.31 Stairs

Except where indicated otherwise in the schedules, all single/multi storey buildings shall have an internal/external staircase up to the roof; the minimum staircase clear width shall be 2.2 metre and the maximum slope about 33˚, 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 2.5 metre 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. Alll 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.

10A.4 CONCRETE WORKMANSHIP

10A.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.

10A.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.

10A.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.

10A.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.

10A.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 weathertight shed at least 300mm off the floor. Regular checks shall be made on the weight of cement in each bag.

10A.4.6 Water

All water used in the preparation of concrete for foundations shall be 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.

10A.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.

10A.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.

10A.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 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.

10A.4.10 Mixing and Placing of Concrete

Proportions of aggregates and cement and the quantity of water for each batch of concrete shall be closely monitored by an experienced mixer operator. Aggregate shall preferably be weight batched but, where this is not possible, volume batching shall be permitted, provided that the net volumes of the loading equipment are approved by the Engineer. Containers for measuring quantities of water shall be clearly marked and only approved quantities of water shall be used in the manufacture of concrete.

Mechanical mixers shall be in good condition and well maintained. After loading, the constituent parts of the concrete shall be mixed together for a period of not less than two minutes or 30 revolutions of the barrel, whichever is the greater. For mixers with a capacity greater than 1.5m^3 these periods may be increased if the Engineer so requires.

When the constituents are adequately mixed, the fresh concrete shall be discharged from the mixer and placed in the foundation with the minimum of delay. Chutes shall be used to ensure that fresh concrete is not dropped by more than 1.5 metres.

No concrete shall be placed until all form work, installation of parts to be embedded, and preparation of surfaces involved in the placing have been approved. No concrete shall be placed in or through water, except with the written permission of the Engineer, and the method of

depositing such concrete shall be approved by the Engineer. Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened for seven days. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, mud or other foreign material, shall be cleaned of all such refuse before the surrounding or adjacent concrete is placed. Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and other foreign matter. The surfaces of concrete which have set, and against which new concrete is to be poured, shall be thoroughly cleaned to remove all foreign material and laitance, and be saturated with water immediately before placing concrete. Concrete shall be deposited continuously and as rapidly as possible until the unit being poured is complete. If for any reason the work is stopped before completing the unit of operation, a construction joint shall be installed in accordance with the instructions of the Engineer. Concrete shall be so deposited as to maintain, until the completion of a unit, a plastic surface approximately horizontal.

The method and equipment used for transporting concrete shall be such that concrete having the required composition and consistency will be delivered as near as practical to its final position without segregation or loss of slump. All concrete mixing and placing equipment and methods shall be subject to approval by the Engineer. Concrete placement will not be permitted when, in the opinion of the Engineer, weather conditions or other pertinent factors prevent proper placement and consolidation.

Bidders are reminded that, as a minimum standard, the following series of inspections should be carried out by the Bidder before concreting can begin:

1 Formwork coated with mould oil and correct in type, quantity and condition

2 Centre lines of template to coincide at the centre peg

3 Formwork to be well strutted and correctly located

4 Vibrator to be in working order

5 Mixer to be in working order

6 There is provision to maintain continuous mixing and pouring, by hand if necessary, in the event of a mixer breaking down

7 Where necessary, re-bar is on site ready bent and complete with tie wire, stirrups and concrete or plastic preformed spacer packs

8 A reliable level is at hand

9 There is sufficient aggregate, cement and water to complete the pour

10 Excavations are safe and not cluttered around the top edges

11 The mixer barrel is clean, and the paddles are complete and in place and the barrel will rotate at the speed specified by the Manufacturer

12 A suitable chute is in place

13 Both an air thermometer and concrete thermometer are on site

14 There is a large quantity of hessian sacking at hand

Where any of the above items are not complied with, the Engineer may suspend concreting pending their implementation.

10A.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.

10A.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.

10A.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.

10A.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.

10A.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.

10A.4.16 Hot Weather Concreting

In hot weather the following additional precautions shall be taken.

(a) In hot weather suitable means shall be provided to shield the aggregate stockpiles from the direct rays of the sun or to cool the mixing water/aggregates to ensure that the temperature of the concrete when deposited shall not exceed 32˚C.

(b) In hot dry weather suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the final concrete.

10A.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.

10A.6 Land development work :

10A.6.1 Land development work shall be carried out by dredged filling material or by carriedearth/viti sand using the following methods:

(a) Land development by dredge filling material:

Land development by dredge filling materials means dredging by cutter suction dredger for collection and direct pumping of dredged fill materials by 18" dia. or more cutter suction dredgers from the pre-selected river bed through pipe line to the proposed fill site in wet and liquefied condition. The dredged material will be placed at site directly and excess water will be removed out of the site. Spreading and compaction of fill material will be carried out in layers. The layer thickness shall be determined on the quality of dredged fill material. Each layer should be compacted to a minimum of 95% optimum density as defined by the Proctor Test.

(b) Land development by carried earth/viti 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.

10A.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.

10A.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 5kg	 5Nos. 5 Nos.
2	ABC dry powder type: 5kg 8kg 15kg(including wheel carriage)	 6 Nos. 4 Nos. 3 Nos.
3	Sand bucket with metal frame	One(1)set with 5 buckets

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT
FOR

Design, Supply, Installa-tion, Testing and Commissioning of 230 KV In-door GIS Substation with 132 kV AIS at Faridpur, and Bay Extension of existing 230/132 kV Barisal (North) AIS Substation on turnkey basis

SECTION 10B
BUILDING AND CIVIL ENGINEERING WORKS (FOR INDOOR GIS)

SECTION 10B

BUILDING AND CIVIL ENGINEERING WORKS (FOR INDOOR GIS)

TABLE OF CLAUSES

SECTION 10B

BUILDING AND CIVIL ENGINEERING WORKS (FOR INDOOR GIS)

10B.1 GENERAL

Under this Section the Contractor will be responsible for the design and construction of all civil engineering and building works and services for new indoor/outdoor GIS substation.

10B.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 equipment to the satisfaction of the Employer. No additional costs will be considered for any items which have been overlooked but which are essential for the proper completion of the project in every respect.

The work shall include but not be limited to:

a) Site survey and subsoil investigation.
b) Site preparation, cutting or filling up to the level specified in 12B.1.4 and leveling.
c) Roadways, car ports, paths and surfacing.
d) Foundations for all equipment to be installed in outdoor switchyards, control building, indoor switchgear and any other building required for the project.
e) GIS and control building (complete building consisting of structural reinforced concrete frames, brick walls, concrete roof and floor slabs) with cable basement.
f) Motorized door for GIS entrance.
g) Floor finishing: screed for cable basement and GIS room, Nitocote epoxy resin coating in battery room, raised floor for control room and homogeneous tile for other floors.
h) Cable trenches, cable tunnels, cable ducts and pipe ducts.
i) Water supply and plumbing installations
j) Surface water and foul drainage.
k) Guard house and fences.
l) Air conditioning and ventilation.
m) Lighting, small power, external floodlighting, emergency lighting and fire protection.

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 Contractor:

a) Septic tank and soakaway
b) Underground water storage tank

Drawing and design of septic tank and soakaway shall be prepared by the contractor and shall be finalized during detailed Engineering.

The Bidder shall state which approved local building contractor(s) he proposes to employ to carry out the work.

10B.1.2 Contractor to satisfy himself as to all conditions

The Contractor shall assess:

a) access conditions at all sites, plus ground conditions and ground bearing capacity
b) transport costs, materials costs and restrictions of availability of supply of materials locally
c) importation restrictions and delay due to customs controls
d) restrictions imposed by existing equipment on sequence of construction, access, etc.
e) restrictions caused by cable laying, equipment and line contractors
f) ground conditions and temporary works required to provide support during excavation

10B.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.

10B.1.4 Site Survey Drawings

For each site the Contractor shall prepare a survey at 1:200 scale showing existing ground levels on a minimum 10 metre grid and details of all features above and below the ground within the site boundary and up to 15 metres 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 submit to approval by the Employer and the agreed substation building floor levels shall be given on each site plan. The Contractor shall propose the building floor level to the Employer. The final site level shall be 500 mm above the nearest public road.

10B.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.

10B.1.6.1 Engineer's and Employer's Accommodation/Surveying Equipment

On each major site The Bidder shall provide an office of approx size 5 x 8m equipped with desk, 2 chairs, light, fan and air conditioner 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.

10B.1.6.2 Surveying Equipment

The Bidder shall loan his surveying instruments to the Engineer and his staff when required. Instrument checks shall be carried out at monthly intervals.

10B.1.7 Programme

The Bidder's programme shall at Bid stage define the following key dates for each site. Where drawings are to be submitted for approval, they shall be submitted at least 6 weeks before the key dates to allow for the Engineer to comment and his comments to be incorporated in the drawings:

a) Issue of approved site survey drawing complete with soil levels and floor levels
b) Issue of approved electrical layout drawings
c) Completion of Site Investigation field work
d) Issue of approved Site Investigation Final report
e) Completion of loading tests on a foundation on each fill site and any other site where settlement is likely to be a problem
f) Issue of approved drawings required for Planning Permission
g) Issue of a full complete set of civil building drawings
h) Construction start date
i) Date access will be given for:
   - Installation of equipment in Buildings
   - Installation of outdoor plant
j) Construction finish date

The Bidder's programme shall outline the number of sites he proposes to build at any time and shall show the order of completion of sites and how crews will move from site to site. This information shall be used to establish the number of expatriate site supervisors required.

The drawing programme shall ensure that complete set of approved civil building drawings will be issued at least 21 days before construction start at any site, 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) given for each site each month. The overall percentage completion of the project each month shall also be given.

10B.1.8 Monthly Progress Certificates/Progress Reports

In accordance with the Project Requirements the Contractor shall submit agreed progress certificates for each site 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 of each site and that site's contribution to overall project percentage completion. An updated 'S' curve shall be submitted with the progress certificates.

10B.1.9 Temporary Facilities

The Bidder shall provide all temporary buildings, workshops, cement and lime stores and latrines required for his use. The Contractor shall agree the location of these buildings with the Employer, after submitting a drawing showing their proposed location.

The 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.

10B.1.10 Site Supervision

Although the civil and building works may be let as a sub-contract to an approved local contractor, the main contractor shall ensure that an expatriate supervisor in his direct employ is continuously available at each 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 in writing of every concrete pour and foundation casting the day before the work starts. This is a Hold Point.

10B.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) 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 for each substation for approval after initially getting the electrical layout of each substation approved. Where possible, drawings shall be standardized and general drawings (00) issued covering several sites.

For each substation The Bidder shall provide a co-ordination plan at scale 1:200 showing structure types, foundation types, cable trenches, roads, ducts, buildings, boundary walls, earthing, drainage and all services in this Contract.

10B.2 REFERENCES

10B.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 Employer. Relevant Standards include, but are not limited to, those listed in sub section 2.2 below.

10B.2.2 Design and Construction Standards

BS 12	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 1	Code 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

10B.3 DESIGN

10B.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 elevations of buildings shall be agreed before other detail plans are prepared.

The general layouts of buildings are to be maintained as shown, but minor modifications may be made to provide buildings wholly suitable for the equipment being provided by the contractor to satisfy the requirements of other parts of the Specification.

All buildings shall be designed to have reinforced concrete frames, with infill panel walls of reinforced concrete or brick which shall be capable of resisting a horizontal earthquake force of 0.2G.

All external walls of control room building/SPR shall be minimum 230mm first class brickwork plus one layer of Mirpur Ceramics or similar approved facing bricks. External walls of other buildings shall be minimum 230mm first class brickwork plus one layer of Mirpur Ceramics or similar approved facing bricks or rendered with cement render and painted as required by the architectural plan.

Internal partition shall be fire barriers rated for minimum 1 hour and of approved material/design. Internal walls shall all be rendered and receive one sealer coat plus two finishing coats of emulsion paint of approved colour.

All brickwork shall be tied into the concrete frame by galvanized ties. Externally, rendered walls shall receive primer plus two finishing coats of PEP acrylic external quality paint or similar approved. At least two air bricks shall be provided to each room in which staff work/rest.

Substation buildings shall be designed to withstand pressure due to internal arcing or arrangement shall be made for pressure release in such an event by providing wall dampers. Parameters considered in the building design shall be subject to PGCB's approval.

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, door 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.

All floor slabs shall be constructed of reinforced concrete supported on reinforced concrete beams. Floor finishes will be designed to provide high impact and abrasion resistance. The finishes shall be in accordance with the schedule of finishes.

Electric overhead traveling crane(s) shall be provided in the 400kV, 230 kV and 132 kV GIS switchgear room to facilitate erection and maintenance of the equipment

The height of control rooms shall provide about 1 metre clearance over the top of the cabinets/equipments to the underside of the false ceiling and any fittings suspended from ceilings shall be the criteria governing room heights. In the switchgear rooms, about 1 metre clearance shall be provided over the switchgear to the underside of the roof slab but the Contractor shall provide a greater clearance if it is required to remove equipment. The clearance maybe reduced below downstand beams provided no equipment is required to be removed from the top of the switchgear.

Rooms shall have walls and roof slabs adequately insulated. Maximum thermal transmittance values for all rooms shall be 0.7 watts/m^2/°C for walls and 0.57 for roofs. Air conditioning units shall be provided in rooms listed in Section 11. 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. Suspended ceilings, with acoustic tiling and incorporating lighting and air-conditioning fixtures shall be used in corridors, offices, toilet, control and communication 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 closuers 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.

Roofs to the main buildings shall be insitu reinforced concrete slab and shall be insulated and waterproofed. 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. The entire roof area shall be laid in one continuous operation. 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 100mm diameter cast iron 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 Contractor 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 to form a sunshade and rain shelter to the walls below. The upper surface of this projection shall be sloped and a drip provided. A steel staircase with necessary landing shall be provided to permit easy access to the roof and to equipment at roof level. Roof mounted equipments (if any) shall be covered by approved screens for better elevation/aesthetics.

The head of each downpipe shall be fitted with an enlarged hopper and purpose made cast iron grill set into a recess in the roof projection.

The roof parapet wall shall be about 0.8 metre high with an insitu concrete coping 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 (Mirpur ceramics or similar approved) to ensure good air circulation over the roof. Three open decorative blocks of size 1000mm X 500mm should be provided on each side in solid portions of parapet wall.

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 a 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 main entrance to all buildings shall be shaded, either by a projection of the roof over the entrance verandah or by a separate roof at a lower level. This area of roof shall also be lime terraced and drained by rainwater pipes.

Substation buildings housing switchgear and control equipment shall include a cable basement to facilitate connection to the equipment. Basements shall be constructed so as to protect the building substructure from water in accordance with BS 8102.

10B.3.2 Cable Basement

Not used.

10B.3.3 Cable Tunnels and Cable Trenches

The Contractor is responsible for all civil works required for the installation of cables.

Main structure of cable tunnel is reinforced concrete and shall be designed enough bearing capacity caused by some parts of cable tunnel are under heavy equipment. Cable tunnel is used for cables from the 230 kV transformers to GIS building.

All cable runs in buildings shall be arranged within the ground floor.

10B.3.4 Ground Conditions, Foundations and Site Investigation

(a) Fill Sites

The Bidder shall impose the site layout on the survey to check for uneven depth of fill below any foundation and where uneven depth of fill exists his foundation proposals shall restrict final differential settlement to a 1 in 400 slope.

If a fill site has not been exposed to one wet season before foundation work starts, the Bidder shall flood the site to a depth of 50mm for 10 days (Not required on hydraulic fill sites). This requirement is because silty sands will generally compact to a denser condition on first time flooding.

On all fill sites the Bidder shall pipe rainwater from down pipes down to paddy level and shall prevent water ponding in open foundations and backfill all foundations as soon as possible.

When a filled site is handed over to the Bidder, the Bidder shall become responsible for maintaining the entirety of the fill in good condition, including all better slopes.

(b) Unfilled Sites

Original delta levels are generally 4 metres below road level. Therefore most sites are historically fill sites but fill settlement can sensibly be considered complete, where fill is over 3 years old.

(c) Site Investigation

Detailed methodology for subsoil investigation shall be submitted before implementing the subsoil investigation. All laboratory tests shall be done at the test facility approved by the Employer.

The Bidder may appoint a sub Bidder to carry out the site investigation but all work and all lab work shall be witnessed by one of his Geo-technical engineer who shall countersign all recorded data.

1 borehole should be counted for every 600 square meter of proposed project area and

provided on suitable points. At least three additional boreholes should be provided for control building and switchyard panel room building or any other building. For boundary wall/retaining wall additional boreholes shall be provided on in each corner point and at a maximum 50m interval point. Additional boreholes may also be required where uneven fill depth is encountered. The number and location of boreholes shall be approved with the site survey drawing showing existing ground levels specified in the section 10A.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, 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 1.0 metre intervals.

- Undisturbed samples shall be taken at around 2 metres depth and 3 metres depth and tested by unconfined compression tests.

- One dimensional consolidation tests shall also be carried out on undisturbed samples taken at 1.5, 3 and 4.5 metres depth. The samples shall be saturated and the range of applied pressure shall fully reflect the insitu conditions. Graphs showing void ratio (e) and applied pressure shall be submitted along with the Coefficient of Compressibility for the range of loading anticipated.

- 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. 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 Contractor shall check the sensivity of soil and ground water at each site to concrete and take all measures necessary to ensure the long term durability of concrete.

Prior to commencement, the Contractor shall submit to the Engineer detailed schedules for the site survey and soil investigation. This is a Hold Point.

(d) Site Investigation Report

The site investigation and analysis of the data in a final report giving full details of foundation proposals shall be completed at each site by the programmed date. During site investigation, Geographical map shall be prepared indicating the locations of soil test.

The report shall be submitted by the key date at each site given in the programme. The Bidder shall submit 3 copies of the report to the Engineer. The report shall propose full details of foundations and loading thereon and shall provide estimates of likely settlements and differential settlements. The report shall be the work of the Bidder's own foundation engineers.

If the Bidder uses a local site investigation Bidder, he shall appoint one of his geo-technical engineer to oversee the entire operation and each piece of data shall be countersigned by this person.

Where estimated settlement exceeds 25mm, the Bidder shall construct one foundation at an early stage and test load this foundation to confirm settlement predictions.

(e) Foundations

Regardless of the result of soil investigation report, the foundations of control building, boundary wall, gantry structures and for auto-transformers shall be provided with piles. Piles shall be concrete (cast-in-situ or precast) complying with BS 8004.

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 70mm minimum thickness of Class B concrete blinding, within 24 hours of bottoming excavation, which blinding shall project 300mm minimum distance beyond all footings. Each footing shall be inspected by the Engineer. Where soil condition is poor (on fill sites or already filled sites) or where the Bidder leaves foundations exposed and soil conditions deteriorate, one of the following measures shall be carried out as agreed with the Engineer:

i) Blinding depth and projection shall be increased as necessary.
ii) Soft soil shall be removed and replaced with compacted viti 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. In addition column footings shall be tied at foundation level and also floor level by beams to every adjacent column in both orthogonal directions.

These beams shall be designed to resist 1 in 200 differential settlement without distress and shall be capable of resisting the earthquake load of 0.2G.

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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 two 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 Contractor 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. 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 rain season, shelters shall be erected over all open excavations.

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 shoring 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, 2.5 kg rammer.

Before starting foundation work the Contractor 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.

On fill sites where the depth of fill exceeds 3 metres, the Contractor shall provide piled foundations in accordance with BS 8004 for substation buildings. One working pile chosen by the Engineer shall be load tested at each site to 150% of design load in accordance with BS 8004.

10B.3.5 Fire Criteria

The Contractor shall make provision in the design of the building structure for minimum periods of fire resistance in accordance with "The British Building regulations 1985 - Part B - Fire - B2/3/4 Fire Spread.

The minimum periods of fire resistance (hours) shall be related to the maximum dimensions, i.e height, floor area or cubic capacity, of buildings or compartments of buildings.

For calculating the maximum dimensions the following definitions shall apply: -

(a) "Area", in relation to a building, means the area calculated by reference to its finished internal faces:

(b) "Basement" means a storey of which the floor is at any point more than 1.2 metres below the finished surface of the ground adjacent to it.

(c) "Floor area" means the aggregate area of every floor in a building or extension, calculated by reference to the finished internal faces of the walls enclosing the areas, or if at any point there is no such wall, by reference to the outermost edge of the floor.

(d) "Height" means the height of the building measured from the mean level of the ground adjoining the outside of the external walls of the building to the level of half the vertical height of the roof of the building, or to the top of the walls or of the parapet, if any, whichever is. the higher.

To restrict the spread of fire, certain walls and floors shall be designated as fire compartment barriers. Fire compartment barriers shall provide complete barrier-to spread of smoke heat and other products of combustion. The barriers shall have a rating of 2 hours minimum. All openings in walls/floors for entry/exit of cables shall be sealed with approved fire sealant rated for minimum 2 hours.

10B.3.6 Drainage

The entire surface within boundary walls shall be of uniform sloping site, sloping at 1 in 300 minimum slope to open channels around the entire perimeter. These channels shall be designed for a rainfall intensity of 60 mm 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 70mm. 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 10A.3.16.

The cable trenches will thus form barriers to surface water drainage. If the cut off area exceeds $30m^2$ it shall be drained by a 200mm minimum diameter concrete 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 700mm. 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 600mm. x 600mm clear openings and airtight 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 80. 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, non 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.

Main control building shall be provided with a septic tank designed for 10 users and a soakaway of open brick construction 11m deep by 2.2m diameter filled with broken bricks. The septic tank shall be located at least 15 metres from buildings. 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. Two vents of minimum height 2.2m shall be provided on each septic tank.

If a town's water supply is unreliable, the roof rain water shall be collected in an underground tank of standard Employer's design.

10B.3.7 Surfacing

For the whole of the switchyard outdoor equipment area the ground shall be surfaced with gravel or other readily available local stone as approved by the Engineer. The switchyard surfacing shall be clean, thoroughly washed when necessary, and free from clay, soil or contaminating material and shall be graded from 20 - 45mm, laid and lightly compacted to a finished thickness of 175mm. Below the gravel 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.

The substation plot, outside of the designated switchgear equipment areas, shall be turfed. Turf shall be of good quality, free from weeds and shall be a minimum of 40mm thick. 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 vegetable soil, 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.

10B.3.8 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 15 cm thickness fitted with construction joints at distances not exceeding 6.0 m. 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 assess all practical requirements like culvert construction, removal of any obstacles, permission from local authorities etc. for access road. All necessary works shall be the bidder's responsibilities.

The width of access road from outside the site boundary to connect to any adjacent public road shall be 6 meters. All roads within the site boundary shall be generally 6 metres wide between the outer edges of kerbs for main road and 4.5 meter & 3 meters wide for sub road.

The road edge shall be formed by Class B concrete kerb 300mm wide by 250mm deep, placed over one layer of bricks laid flat. The road shall be a Class A concrete slab of average

150mm deep at each edge with 1:50 cross fall and stiff broom concrete finish reinforced with 8mm bars at 125mm centres longitudinally and 8mm bars at 125mm centres transversely placed 60mm below the upper surface. Expansion and contraction joins shall be detailed on site plans. Expansion joints shall have oil resisting grade polysulphide 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.

10B.3.9 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 tubewell 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 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 galvanised steel 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.

10B.3.10 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 300mm 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 10 gallon 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.

10B.3.11 Substation 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 sandThe 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 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 minimum 100mm 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.

Each 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 GIS room and battery room shall 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.

10B.3.12 Cable Basement and GIS Room Floors

No cable basement shall be used. Cables shall enter into the building through ground floor. GIS room shall have a concrete floor finished by 25mm cement screed in composite method of construction. To avoid cracks, joint of adequate size are to be made at suitable points. Screed shall correspond with expansion joints in floor slab. Additional screed joints like sawn joints, additional expansion joint etc. shall be avoided. To improve the resistance to abrasion and to reduce dust accumulation, the screed shall be coated with synthetic resin based paint unless specified otherwise.

10B.3.13 Control Room Floor

No raised floor shall be used.

10B.3.14 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.

10B.3.15 Site Clearance, Obstructions and Adjacent Structures

The Contractor shall be responsible for clearance of:-

(1) Trees, shrubs and any vegetation including the extraction of all roots and compaction of backfill where roots have been extracted.

(2) The removal of all buildings, sheds or any other structures above or below ground including the removal of any septic tanks, drains or other underground services.

(3) The removal of any existing surfacing, roads, foundations or any other obstruction.

All material cleared away by the Contractor shall be the property of the Employer and shall be removed by the Contractor to a site in the Dhaka area upon instructions of the Employer. The Employer may remove any buildings or structures himself from sites before the site is handed over to the Contractor.

Where an existing service, existing equipment or adjacent building is to be retained, the Contractor 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 Contractor shall take all necessary measures to build in the service at no extra cost.

10B.3.16 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 Bidder 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 Bidder shall erect a permanent fence 2.0m high in accordance with BS 1722 part 10 or similar approved.

10B.3.17 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 below 2.5 metres 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 500mm 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.

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.

10B.3.18 Doors

Internal doors and door frames shall be anodised aluminium. Main Entrance/Exit doors and door frames shall be steel.

External doors shall be of aluminium. Fire rated doors shall be in accordance with NFPA 80 and shall be of standard construction. Doors shall be dust-proofed by use of neoprene or other approved seals.

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 2500mm. 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 door leaf shall have three 150mm heavy iron hinges equally spaced. 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 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.

For the GIS entrance gate at GIS room, the gate shall be electrical motorized horizontal or vertical door. Before commencement of installing, the contractor shall submit a detailed drawings and specifications of motorized door for Employer's approval. This is a Hold Point.

10B.3.19 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 1:1: 5 to 6. cement, lime, sand.

All brick panels shall be tied to the concrete frame with galvanised ties of approved design. Ties shall be painted with bituminous paint.

Facing bricks shall be 200 x 62 x 25 mm facing bricks from Mirpur ceramics. Facing bricks shall be tied back to the main wall. 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 with maximum variation of 0.75m. 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, two 6mm bars per course extending 900mm beyond the opening both sides where possible.

All exposed brickwork shall be rendered and painted where not faced with facing bricks.

10B.3.20 Expansion Joints, Joint Fillers and Sealants

Not used.

10B.3.21 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 50mm 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 below the trench at low points; 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 weight less than 55 kg. The minimum depth shall be 70mm, with downstand 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 Contractor 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.

10B.3.22 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:

i) a small open channel conveying the water to the boundary channel

ii) a pipeline conveying the water off the site. Rainwater shall not be connected to the septic tank or allowed to discharge directly onto switchyard paving.

10B.3.23 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 weatherproofer 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.

10B.3.24 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.

Carriage way is required to be provided with rail connected to all transformer bases. Transformer shall be anchored in such a manner so that it can prevent the movement of transformer for 0.2G ground acceleration.

10B.3.25 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. 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 same 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.

10B.3.26 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 buildings, boundary walls and guard posts shall be painted with a fungicide, Snowcem primer and two coats of Snowcem. All exposed facing bricks and Snowcem 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 two 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, including all brick ties, boundary wall wire supports, crane beams, 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.

10B.3.27 Furniture

The Contractor shall supply a complete set of tables, chairs, stools, desks, benches, storage shelves and drawing cabinets as described in the Project Requirements with layout top, for drawing examination, lockable cabinets for spares and test equipment and key boxes in each 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 Contractor 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.

10B.3.28 Concrete

Only two grades of concrete shall be used. Class A shall be used for all structural work, piling and for all foundations. Class B concrete shall be used for blinding, pipe surround and unreinforced or nominally reinforced concrete. Road slabs and floor slabs shall all be Class A reinforced concrete.

	Class A	Class B
Min Cement Content	360kg/m^3	170kg/m^3
Max Water Cement ratio	0.55	-
Coarse Aggregate type	Broken stone	Jhama brick
Max Coarse aggregate size	20mm (40mm piling)	25mm
Method of Batching	Volume batching	Volume batching
Min Characteristic of Trial Mix at 28 days	30N/mm2	-
Min characteristic strength of trial mix at 7 days	14N/mm2	-
Min characteristic strength of works cubes at 28 days	20N/mm2	-
Slump Range	30mm min-100mm max	50mm min
Slump for concrete placed below water in piling	150mm min	

It should be noted that minimum specified cement content will produce significantly stronger concrete. The Contractor's design shall be based on a 28 day crushing strength of 20N/mm^2. Design shall be in accordance with this Contract and BS 8110 or other agreed standard.

For all types of foundation work high tensile steel shall be used (minimum characteristic strength 415 N/mm^2) 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, 100mm where concrete is cast against soil, and 30mm 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 scrabbled. All joints shall be horizontal or formed against vertical stop ends. 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**.

10B.3.29 Concrete Reinforcement

The Contractor 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 6mm 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 Contractor 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.

10B.3.30 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.

10B.3.31 Lifting Beams

In substation buildings a galvanised steel lifting beam shall be provided for hoisting equipment to all upper floors. The beam shall be fixed permanently in place and shall project the required distance from the building to lift the largest equipment from road transport. Beams shall be designed in accordance with BS 2853 and deflection shall be limited to 1/900th of span. An approved (Morris of Loughborough 190 Series with Morris 164 travelling trolley or similar approved) hand chain hoist with hand geared travel and travelling trolley of capacity to suit the heaviest equipment or future equipment shall be provided on each beam. The chains shall reach to lorry level and provision shall be made to hang up the chains to one side when not in use.

Inward opening doors shall close around the beam and be shaped to a close fit.

10B.3.32 Stairs

Except where indicated otherwise in the schedules, all single/multi storey buildings shall have an internal/external staircase up to the roof; the minimum staircase clear width shall be 2.2 metre and the maximum slope about 33˚, 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.

GIS building shall have one internal and one external staircase for fire escape, which shall have a minimum clear width of 2.5 metre with a maximum slope of 30˚, all detailed in accordance with BS 5395. External/fire staircases shall be enclosed and shall be completely protected against rain by roof projections; steps shall be open with non slip nosings. All 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). In GIS building, provision for a lift of capacity of 6 persons should be provided.

All roofs which are not accessible by stairs shall be provided with a galvanised steel fixed ladder.

10B.4 CONCRETE WORKMANSHIP

10B.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.

10B.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 Contractor proposes to use contains an excess of fine particles or any harmful substances, the Contractor 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 Contractor 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.

10B.4.3 Sampling

At least four weeks before he envisages first receiving aggregate from any source the Contractor, 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 Contractor's expense and may include the manufacture, both in the laboratory and at site, of test cubes or cylinders to determine crushing strength.

10B.4.4 Grading

The Contractor 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 Contractor shall submit in writing to the Engineer the make up 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.

10B.4.5 Cement

Portland Composite Cement shall comply with BS 12. The Contractor 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 12. All cement shall be stored in a weathertight shed at least 300mm off the floor. Regular checks shall be made on the weight of cement in each bag.

10B.4.6 Water

All water used in the preparation of concrete for foundations shall be 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.

10B.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 Contractor 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.

10B.4.8 Storage

The Contractor 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 Contractor establishes central depots for receiving cement prior to dispatch 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.

10B.4.9 Design Mix

Prior to ordering any aggregate the Contractor shall inform the Engineer of the source(s) of his aggregates and deliver samples to the Engineer. The Contractor will authorise at an approved laboratory tests to show the sieve analyses, relative densities, moisture content 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. The contractor shall be entirely responsible for the control of the quality of concrete mixed and placed. Before the commencement of any concrete design mix, the Contractor shall submit to the Engineer the details of the material used, source of the supply, storage and quality control requirements, including preliminary trail mixes and works' tests. This is a Hold Point.

Depending on the moisture content of the samples of aggregate the Contractor 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 Contractor 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. This is a Hold Point. The minimum 28 day crushing strength of any such test specimen shall be not less than 20N/mm2.

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 Contractor at his own cost.

10B.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 1.5m3 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 Contractor before concreting can begin:

1 Formwork coated with mould oil and correct in type, quantity and condition

2 Centre lines of template to coincide at the centre peg

3 Formwork to be well strutted and correctly located

4 Vibrator to be in working order

5 Mixer to be in working order

6 There is provision to maintain continuous mixing and pouring, by hand if necessary, in the event of a mixer breaking down

7 Where necessary, re-bar is on site ready bent and complete with tie wire, stirrups and concrete or plastic preformed spacer packs

8 A reliable level is at hand

9 There is sufficient aggregate, cement and water to complete the pour

10 Excavations are safe and not cluttered around the top edges

11 The mixer barrel is clean, and the paddles are complete and in place and the barrel will rotate at the speed specified by the Manufacturer

12 A suitable chute is in place

13 Both an air thermometer and concrete thermometer are on site

14 There is a large quantity of hessian sacking at hand

Where any of the above items are not complied with, the Engineer may suspend concreting pending their implementation.

10B.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 Contractor 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 + 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/mm2 within seven days after mixing and 20N/mm2 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 Contractor's expense, or the Engineer may allow the Contractor 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 Contractor has made suitable repairs to the part disturbed by taking the sample, accept the concrete.

In addition to cube sampling, 30% of concrete pours shall be tested by Schmidt Hammer. The Contractor is to pay for all remedial work and testing. Readings shall be taken at locations agreed with the Engineer and shall be witnessed by the Engineer. At least 15 readings shall be taken such that, after discarding the highest and lowest, some 12 readings remain from which the mean shall be calculated. Readings shall be restricted to the middle third of a beam, slab or column and shall not be closer than 50mm to an edge or closer than 50mm to any other readings. Immediately on completion of hammer testing, the concrete surface shall be painted to seal it with two coats of snowcem primer.

10B.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.

10B.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.

10B.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.

10B.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.

10B.4.16 Hot Weather Concreting

In hot weather the following additional precautions shall be taken.

(a) In hot weather suitable means shall be provided to shield the aggregate stockpiles from the direct rays of the sun or to cool the mixing water/aggregates to ensure that the temperature of the concrete when deposited shall not exceed 32°C.

(b) In hot dry weather suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the final concrete.

10B.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 Contractor 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.

The contractor shall submit to the Engineer a comprehensive method statement giving sequential details of his proposed installation method and include his intended program. The method of statement shall include the following details, but not limited;

(a) Method of excavation and dealing with water
(b) Method of pre-heating, welding and site bending of reinforcement
(c) Method of placing of concrete
(d) Method of curing and protecting the concrete
(e) Method of backfilling and compacting
(f) Method of floor finishing
(g) Method of motorized door for GIS entrance
(h) Reinstatement of working areas
(i) Quality control procedure
(j) Site safety procedure

This is a **Hold Point**.

10A.6 Land development work :

10A.6.1 Land development work shall be carried out by dredged filling material or by carriedearth/viti sand using the following methods:

(a) Land development by dredge filling material:

Land development by dredge filling materials means dredging by cutter suction dredger for collection and direct pumping of dredged fill materials by 18" dia. or more cutter suction dredgers from the pre-selected river bed through pipe line to the proposed fill site in wet and liquefied condition. The dredged material will be placed at site directly and excess water will be removed out of the site. Spreading and compaction of fill material will be carried out in layers. The layer thickness shall be determined on the quality of dredged fill material. Each layer should be compacted to a minimum of 95% optimum density as defined by the Proctor Test.

(b) Land development by carried earth/viti 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.

10A.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.

10A.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/upgradation AIS and 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 5kg	 5Nos. 5 Nos.
2	ABC dry powder type: 5kg 8kg 15kg(including wheel carriage)	 6 Nos. 4 Nos. 3 Nos.
3	Sand bucket with metal frame	One(1)set with 5 buckets

SECTION 11

SUPPORTING STRUCTURES FOR OUTDOOR EQUIPMENT

TABLE OF CLAUSES

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 the primary connections between major components shall be bolted, for ease of transportation and erection.

Low level support structures shall be either lattice structures primarily composed of angle sections or 'moment' type structures primarily composed of welded hollow or composite sections.

The design and arrangement of supporting structures shall be subject to approval by the Engineer.

The type of arrangement of high level structures and acceptable materials for both high and low level structures shall be as specified in the Schedule of Technical Requirements.

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.

The assumptions made in the overall structural design especially in the load transfer betwee n 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)

(a) 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;

(b) The wind pressure specified in the Schedule of Technical Requirements applied to the projected area of all members of the windward face of structure;

(c) Where appropriate the conductor and/or earthwire tensions or busbar forces, including due allowance for both horizontal and vertical deviations /inclinations;

(d) Self weight of the equipment and structure;

(e) When stated in the Schedule of Technical Requirements the effects of the specified radial ice thickness shall be taken into account in the determination of the wind area of the conductor, earthwire, busbar, electrical equipment and the supporting structure, the conductor and earthwire tensions and the self weight of the equipment and the structure.

The wind directions considered shall include transverse, longitudinal and if appropriate 45˚ to the major axis of the structure.

Load Combination 2 - Still Air, Short Circuit, Minimum Temperature or Maximum Operating Temperature

(a) Conductor and/or earthwire tensions or busbar forces including the dynamic affects calculated in accordance with IEC 865-1.

(b) Self weight of the equipment and structure;

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)

(a) Conductor and/or earthwire tensions or busbar forces;

(b) Seismic forces;

(c) Self weight of the equipment and structure;

(d) When stated in the Schedule of Requirements the effects of the specified radial ice thickness.

Seismic forces shall be applied as a static horizontal force transversely and alternatively longitudinally to the major axis of the structure, and shall be equal in value to the seismic coefficient stated in the Schedule of Technical Particulars multiplied by the self weight of the conductor, earthwire, busbar, electrical equipment and structure, and applied at the centre of gravity of the equipment and structure as appropriate.

Load Combination 4 - Still Air, Erection, Coincident Temperature

(a) Conductor and/or earthwire tensions or busbar forces;

(b) Self weight of the equipment and structure.

For erection conditions any one complete phase conductor bundle or busbar or earthwire shall be assumed not to be erected in any one span.

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.

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 qref N/m2 at a height of 10m above ground level shall be subjected to variation for height and shape of the structure or equipment under consideration to give the total wind load.
The total wind load on the structure or equipment surface shall be determined from the expression:

The total wind load on the structure or equipment surface shall be determined from the expression:

$$F_{w} = q_{ref} \left[\frac{H}{10}\right]^{2\alpha} C_{shp}\, W_A$$

where F_w = 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

C_{shp} = aerodynamic shape factor

W_A = windward face area of the structure or equipment

The aerodynamic shape factor Cshp shall be as specified:

Flexible conductors	1.0
Earthwires	.2
Tubular busbars Re < 4.1×10^5	1.2 [1]
4.1 x 105< Re < 8.2 x 105	0.6
Support insulators, porcelain for apparatus or cap & pin insulator strings	1.2 [2]
Flat truss structures consisting of profiles	1.6
Square & rectangular lattice towers & supports consisting of profiles	2.8
Sharp edged structures & components other than above	2.0
Flat truss structures consisting of tubes	1.2
Square & rectangular lattice towers & supports consisting of tubes	2.1

Notes: [1] Re = Reynolds Number
[2] Based on external diameter of insulator.

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 of the substation earthing grid shall be provided on the vertical face of the structure, approximately 300mm above the top of concrete. Foundation holding-down bolts shall not be used for the attachment of earth connections.

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 not more than 450 mm centres starting as near as practicable to the base and continuing to within 1m below the top of the structure. It shall be noted on the erection drawings that all step bolts are to be removed after construction for a distance of 2.0m above ground level. Adequate clearance shall be provided between the step bolts and any obstructions which might interfere with their use. Step bolts shall not be less than 16mm diameter, project not less than 150mm, and be fixed with nut, washer and nut.

Where specified ladders of an approved type generally in accordance with the requirements of BS 4211, 450mm wide and 350mm rung spacing shall be fitted to supporting structures. They shall be incorporated into the structure either integrally or separately. Where specified cage protection or fall arrest systems shall be fitted to the ladder. Means shall be provided to prevent unauthorised access of ladders.

Intercircuit screens shall be provided where necessary to prevent access between adjacent circuits on multi-bay structures. Inter-circuit screens shall be fabricated from a 50mm x 50mm mesh formed from 3mm diameter galvanised steel wire.

All structures shall be fitted with identification/notice plates as appropriate.

11.3.8 Structural Design

The allowable ultimate unit stresses used in the determination of the nominal member strength of supporting structures shall be based on the following:

Lattice steel structures	ANSI/ASCE 10-90
Steel A frame or moment structures	BS 5950
Aluminium structures	BS 8118: Part I

Partial factors to be applied to member nominal strength determined in accordance with the above stated codes shall be as specified in the Schedule of Technical Requirements. For ANSI/ASCE 10-90 the appropriate reference stress levels shall be based on the values specified in BS 5950.

The maximum allowable slenderness ratios shall not exceed the following:

	Steel /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 Design Submissions

The Bidder shall submit all design calculations, drawings 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.

11.6 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

11.7 QUALITY CONTROL

11.7.1 General

Routine tests on raw materials and fabricated individual members shall be undertaken in accordance with BS EN 10025, BS EN 10210 and BS 8118 as appropriate.

All steel ex-mills or received from merchant's stock shall be marked to identify the cast or casts from which it was rolled in accordance with Section 9 of BS EN 10025 and Section 10 of BS 102 10, and shall be covered by the appropriate (mill) certificate. The optional impact test BS EN 10210 option 1.6 for quality JO is required.

The material grades or alloy categories of individual pieces of steel/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.

11.7.2 Welding

Unless specified to the contrary all structural welds shall be undertaken using approved welding procedures in accordance with BS EN 288. All welders shall be tested to the requirements of BS EN 287.

All welding shall be subject to a non-destructive testing (NDT) programme, which shall include visual, ultrasonic and magnetic particle testing as appropriate. Visual inspection shall be in accordance with BS 5289, ultrasonic to BS 3923 and magnetic particle to BS 6072. Acceptance criteria shall be in accordance with BS 5135, except for porosity and BS 8118: Part 2. All welds especially butt welds must be continuous to ensure a pickle-tight connection when galvanised.

The Bidder's NDT programme shall be submitted to the Engineer for approval prior to the commencement of fabrication.

11.7.3 Check Erection

Prototype structures shall be check erected in order to verify the accuracy of detailing and fabrication.

The degree of check erection shall be sufficient to verify not only the main structure, but all auxiliary steelwork. Sufficient blocking and support shall be provided to prevent distortion and overstressing of members to ensure proper fit. Assembly shall be accomplished without extraordinary effort to align bolt holes, or to force pieces into position. Bolt holes shall not be reamed or enlarged. Any damage to protective coatings during check erection if the check erection is undertaken on coated structures, shall be recoated at the fabricator's cost.

11.7.4 Galvanising

Tests on galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS 729.

11.7.5 Tolerances

The fabrication tolerances after galvanising for steel members, which are not to be considered cumulative shall be as follows:

(a) On linear dimensions of nominal sections as per BS 4, BS 4848, BS EN 10024, BS EN 10034 & BS EN 10056-2.

(b) On overall length of member ± lmm

(c) On centres of holes ± lmm

(d) On groups of holes ± 2mm

(e) 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

(h) Taper on the punched holes as measured between the specified hole diameter on the punch side and the hole diameter on the die's side (in the black) ± 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.

11.8 ERECTION

The Bidder shall when requested provide the Engineer with a Method Statement detailing his proposed erection methods. Due cognisance shall be taken of the relevant parts of BS

5531 and current health and safety legislation.

All structural members stored on site shall be kept clear of the ground where possible. Contact with substances likely to attack the protective coatings shall be avoided and all members kept in a clean and tidy condition. Care shall be taken to prevent damage/deterioration of any protective coating during transportation, storage and erection. Unless otherwise agreed damaged members shall be replaced. The renovation of damaged areas of protective coatings shall be carried out using techniques agreed with the Engineer.

The Bidder shall ensure that the structures are not strained or damaged in any way during erection. Structures shall be erected vertically within a tolerance at the top, or the centre of the beam of 0.5% of the overall structure height before equipment installation or conductor/busbar stringing.

APPENDIX TO SECTION 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 Subconductor	kN	7.0	4.5
	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	-
4.	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
6.	**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		
8.	**Protective Treatment** [clause 11.6]		
	Galvanising thickness µm	85	N/A
	Protection procedure	BS 729	No

SECTION 12

LIGHTING, SMALL POWER, HEATING AND VENTILATION

TABLE OF CLAUSES

SECTION 12

LIGHTING, SMALL POWER, HEATING AND VENTILATION

12.1 SCOPE

This section of the Specification includes for the interior and exterior lighting, small power, heating and ventilation systems.

Whenever practicable, fixtures shall be sourced locally. All lamps, fittings, plugs, sockets and general accessories of the same size and types shall be similar and interchangeable throughout the installation.

The lighting and small power equipment and installation shall comply with other sections of this Specification as appropriate.

All civil works associated with this section of the works shall be deemed to be included as part of the works in this section. No additional payments will be made for such requirements.

The requirements of this section of the works are subject to the Main Conditions and Specifications laid down in other sections of the Bid Document.

12.2 REFERENCES

British Standards

BS 7671	Code of Practice Regulations for Electrical Equipment in Buildings 15th Edition. Institution of Electrical Engineers.
BS 6004	Specification for PVC insulated cables (non armoured) for electric power and lighting
BS 6346	Specification for PVC insulated cables for electricity supply
BS 6500	Specification for insulated flexible cords and cables
BS 6121	Mechanical cable glands
BS EN 60947	Specification for control gear for voltages up to and including 1000V AC and 1200V DC
BS 4533	Luminaries
BS 3677	Specification for high pressure mercury vapour lamps
BS 1363	Specification for 13A fuse plugs and switched and unswitched socket outlets
BS 1362	Specification for general purpose fuse links for domestic and similar purposes (suitable for use in plugs)
BS 4568	Specification for steel conduit and fittings with metric threads of 150 form for electrical installation
BS 4066	Test on Electric cable under fire conditions.
BS 4434	Specification for safety aspects in the design construction and installation of refrigerating appliances and systems.
	Institution of heating and ventilation Engineers Guide to current practice.

	American Society of Heating Refrigeration and air conditioning Engineers
	Recommendations
	Heating and Ventilation Contractors Association of U.K. specification DW/ 121
BS 5970	Code of Practice for thermal insulation of pipework and equipment
BS 848	Fans for general purposes
BS 6540	Method of test for atmospheric dust spot efficiency and synthetic dust weight arrestance
BS 2871	Specification for copper and copper alloys: tubes
BS 1470	Specification for wrought aluminium and aluminium alloys for general engineering purposes, plate, sheet and strip

12.3 DEFECTS LIABILITY PERIOD

The Contractor shall be responsible for the efficient and good working of the installations comprising this section of the Specification for the agreed period as set out in the Specification document.

12.4 APPROVALS

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the designs of the specified systems which shall be shown on the working drawings, also to be submitted for approval.

Any approvals shall not, however, relieve the Contractor of his contractual responsibilities which include obtaining local authority approvals for electrical wiring installations.

12.5 LIGHTING REQUIREMENTS

The lighting installations shall be designed to give the standard service illuminations and shall incorporate emergency lighting where indicated. Control rooms, relay rooms, telecommunications equipment rooms, offices and stores shall have the service illumination measured at 850 mm above finished floor level. All other areas shall have the service illumination measured at floor level.

The installations shall also meet the limiting glare index requirements as set out in the specified codes of practice. This section of work gives proposals for the types of lighting fittings to be used in the area, type of control to be employed, number of socket outlets and the types of mounting expected to be suitable for the respective areas. Where discharge and fluorescent light sources are to be used in areas containing rotating or reciprocating machinery, the fittings shall be allocated between the 3 phase and neutral in such a manner as to avoid stroboscopic effects. When 3 phase lighting installations are to be used, contactor switching controlled by pushbuttons located in the area to be illuminated is preferred.

In all rooms and corridors having two entrances the lighting installation shall have two way switching, the switches being located in appropriate positions adjacent to the entrances.

Emergency lighting shall be arranged to illuminate all stairways, exits and entrances and provide some illumination in operational areas within the control building and the switchyard, e.g. circuit-breaker and transformer locations.

Security lighting shall be installed around the perimeter walls illuminating the external area and shall be controlled from the gatehouse. The level of illumination for security lighting shall be measured at a distance of 3 metres outside the boundary wall.

12.6 SCHEDULE OF DESIGN REQUIREMENTS

The lighting system shall include provision for ease of erection, maintenance, cleaning, lamp replacement and future extension. Lamp replacement and maintenance should, unless otherwise approved, be possible without necessitating outages on main plant items.

Lighting apparatus shall be of top quality, designed to ensure satisfactory operation and service life under all variations of load, frequency and temperature. Sodium discharge lighting shall be used for road and security lighting. Switchyard floodlighting shall use 500W Halogen lamps unless otherwise specified.

Key to Abbreviations:

L	Local switches
S1, S2 etc.	Socket outlets or fused spur circuits
P.B	Pushbutton for remote control
T.S	Time switch control
C	Ceiling mounted
W	Wall mounted
P	Pole or earth mast mounted
M	Recessed modular mounting
D	Suspended
F	Flush installation
S	Surface installation
A	Automatic on mains failure.
BH	Behind ceiling diffuser.

12.7 CODING SYSTEMS

The Contractor shall, when preparing drawings showing the respective designs, use a code to identify each lighting fitting and socket outlet.

The code shall comprise letters and figures so compiled that the following information can be readily identified:-

1. The lighting distribution board to which the fitting or socket outlet is connected.
2. If connected to the normal supplies or to the emergency DC supplies.
3. The circuit number and phase of the distribution board to which the fitting is connected.

4. The sequence of the fitting in a particular circuit.

12.8 DISTRIBUTION BOARDS

The distribution boards and all component parts shall be manufactured and tested in accordance with the latest standards and designed to suit the fault level of the transformers supplied. The Contractor shall demonstrate by calculation that this has been complied with.

Each, current carrying component shall be so designed that under continuous rated full load conditions in the climatic conditions at Site the maximum total temperatures permitted under the relevant Standards are not exceeded.

Each distribution board shall have a rustproof metal case of sheet steel with either a galvanised or enamelled finish. The colour of the enamel finish shall match the colour of other switchgear. The metal casing is to be provided with a number of knock-outs or other approved form of cable entries, corresponding to the circuit capacity of the distribution board, and a suitable screened brass earthing stud.

Busbars, including neutral bar, shall be of high conductivity copper supported to withstand all normal and fault condition stresses.

All busbars, neutral bars and primary conductors are to be PVC sleeved in respective phase and neutral colours.

Distribution boards for exterior use shall be galvanised and weatherproof.

Neutral bars shall have an appropriate number of ways relative to the size of the board. They shall have a rating not less than that of the associated phase busbars.

The metal surface adjacent to any live part and all spaces between phases shall be protected by barriers of fireproof insulation material.

The distribution boards shall be either single pole or triple pole and neutral types and shall be equipped with means to provide overcurrent protection to each circuit. This protection may comprise an HRC fuse or a miniature circuit breaker, both of which shall be removable without exposing live connections.

Fuse bases and bridges, where used, shall be of an approved non- hygroscopic insulation suitable for the receipt of HRC fuses.

Residual current circuit breakers shall be incorporated to protect all lighting circuits, socket outlets and supplies to appliances, etc. These shall comply with the requirements of the main electrical part of this Specification.

The current rating of the busbars in each distribution board is not to be less than the sum of maximum current rating of all outgoing circuits. The neutral connection for each circuit is to be direct to the neutral busbar.

Title labels of an approved type and inscriptions are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit lists shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit lists. The lists and cover are to be easily removable to permit circuit modifications.

The cables feeding the distribution boards will be connected directly to the incoming isolator or neutral bar as appropriate, unless otherwise indicated by the Specification.

Switchfuse units or isolators connected on the incoming side of a distribution board shall be mechanically attached to the board with solid copper electrical connections between the units. A suitable insulated barrier is to be supplied to prevent copper or carbon dust released under fault conditions passing from one unit to the other.

Distribution boards for use on the direct current system shall be double pole types equipped with adequately rated fuses.

Mixed capacity boards shall be employed and all contactors and time switches associated with the respective outgoing circuits shall be accommodated within the distribution board.

12.9 MINIATURE CIRCUIT BREAKERS

Miniature circuit breakers shall comply with the requirements of the main electrical part of this Specification.

12.10 CABLES

Cables shall be XLPE insulated, single wire armoured and PVC sheathed overall and be manufactured and tested in accordance with the requirements of BS 5467, 600/1000V grade or equivalent. The outer sheath shall be coloured black and incorporate flame retardant characteristics to meet the requirements of BS 4066 and IEC 60332. Jute fillings will not be permitted. Cables shall comply with the requirements of the cable section of this Specification.

Flexible type cables for pendant cords and final connections to fixed apparatus are to be butyl or silicone rubber insulated and sheathed, manufactured and tested in accordance with the requirements of BS 6500, 300/500V or 300/300V grade as applicable.

The conductor is to comprise multi-strands of 0.25 mm wire. The number of strands are to be not less than 30 and in all cases of a number suitable for the protection rating of the respective circuits.

All cables used for lighting and small power shall have copper conductors.

The Contractor is to select conductor sizes for the respective final circuits to meet the following conditions:-

(a) That the minimum conductor size for lighting circuits is to be 1.5 mm2 and for socket outlets 2.5 mm2.

(b) That the size is to be adequate for the current to be carried as set out in the cable manufacturer's specification.

(c) That the size is sufficient to keep the voltage drop in the phase and neutral conductor to the farthest lighting or power point, under normal full load conditions, to within the final circuit limit specified in BS7671. Diversity will not be allowed.

12.11 CABLE TERMINATIONS

Terminations for cables shall comprise compression type glands with armour and bonding clamps to meet the requirements of Type E1 to BS 6121, or equivalent, and are to be designed to secure the armour wires, to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The glands are to project at least 10 mm above the gland plate to avoid moisture collecting in the cable crutch.

Earth bond terminal attachments are to be provided.

Terminations for rubber insulated cables are to comprise compression type glands where the function of the gland is to secure the outer sheath of the cable, in accordance with the requirements of Type A2 to BS 6121 or equivalent. A watertight seal is to be provided between the outer sheath and the gland.

Only one cable is to be terminated in each gland.

3.12 SEALING AND DRUMMING

Immediately after the works tests, both ends of all cables shall be sealed against the ingress of moisture, dirt and insects and the end projecting from the drum shall be adequately protected against mechanical damage during handling and shall be fitted with a pulling eye bonded to cores, sheath and armours.

12.13 CONDUIT

All wiring shall be installed in screwed heavy gauge welded steel conduit or heavy gauge PVC conduit, at the discretion of the Engineer. No conduit less than 20 mm diameter will be permitted.

Surface mounted - steel - switchrooms, battery rooms, i.e.painted blockwork.

Flush mounted - PVC - relay control rooms which have adecorative finish.

Steel conduits shall be manufactured in accordance with BS 4568, Part 1 or equivalent, heavy

gauge screwed and welded Class B and shall be galvanised. Conduit fittings are to be

manufactured of good quality galvanised malleable cast iron and of small circular pattern to BS

4568, Part 2 or equivalent, with internally tapped spouts minimum length 21 mm. threaded to the correct length at intersections, tees, draw throughs and stopends.

Conduit fittings of PVC shall be of the plain bore pattern suitable for a push-on compression type joint-and shall be sealed with a hard setting vinyl cement to prevent ingress of vermin, water, dust, etc. Inspection bends, solid or normal bends, elbows or tees are not to be used except with the approval of the Engineer.

Conduit runs shall, wherever possible, be concealed in ceilings, voids and walls, chases etc., and in rooms of secondary importance (with back outlet entries to switch boxes etc. especially on fair faced brickwork) otherwise the conduits shall be securely fixed to the surface of walls using heavy cast distance saddles. Where plastered finishes are called for, buried conduit systems shall be provided.

Where the system of wiring is concealed, the 'loop-in' system of conduit shall be used and the 'looping-in' boxes shall conform to BS 31, Class B3.

A separate insulated earth conductor, coloured green and yellow, shall be run in PVC conduits and such facilities shall be provided at all terminal points.

Wherever the installation is specified as being flame-proof, the conduit runs entering these areas shall have a barrier box inserted in the run immediately before the conduit passes into the flame-proof area. All conduit work inside the flame-proof area shall be carried out with solid drawn galvanised conduit and all conduit fittings, sockets and accessories shall be galvanised and certified suitable for Group 1 hazard. At the completion of the wiring all machine faces on accessories shall be thoroughly cleaned and greased, prior to the screwing or bolting of all accessory cover plates into their final flame-proof secure position.

The ends of all steel conduits shall be reamered to remove all burrs or sharp edges after the screw threads have been cut. All dirt, paint or oil on the screw threads, the conduit, sockets and accessories must be removed prior to erection. All conduits shall be swabbed through prior to installation of cables.

The ends of the conduit shall butt solidly in all couplings. Where they terminate in fuse-switches, distribution boards, adaptable boxes or non-spouted switch boxes, they shall be connected thereto by means of smooth bore male brass bushes, compression washers and sockets. All exposed threads and all bends shall be painted with an aluminium spirit paint after erection.

All conduit and accessories, after being installed, shall be examined and all parts where the surface has been chipped or scratched shall be painted.

All conduits shall be kept 80 mm clear of water, gas and other services. Should this prove impracticable, then they shall be properly bonded by means of pipe clamps or other device ensuring mechanically sound, electrically continuous connection.

The method of installing PVC conduit and fittings shall conform strictly to the manufacturer's recommendation. These recommendations shall be submitted when seeking approval to the system proposed. In general the clauses dealing with steel conduit shall apply.

PVC tube not exceeding 25 mm in diameter shall be bent cold by means of the appropriate spring and the tube shall be saddled as quickly as possible after bending. When bending larger sizes of tube, the tube must be heated in an approved manner until it is pliable. A 90˚ bend shall have a radius of not less than five times the outside diameter of the tube.

Joints between conduits and conduit fittings shall be watertight and shall be made by means of a solvent adhesive as recommended by the manufacturer. Care shall be taken to ensure that the tube is clean and free from damp and grease and in particular dust, mould and oil.

The Contractor shall provide PVC tube ends and flexible covers to prevent ingress of concrete grout into the tubing and boxes.

All bends are to be made on Site to suit conditions and not more than two right angle bends will be permitted without the interposition of a draw box. No tees, elbows, sleeves, either of inspection or solid type, will be permitted. Generally long straight conduit runs from point to point shall have draw boxes installed at maximum intervals of 10 metres.

Deep boxes or extension rings on standard circular conduit boxes shall be used where necessary in order to bring the front of each box flush with the surface of the ceiling or wall. Where conduits are laid direct on the shuttering of the reinforced slab construction, conduit extension rings or deep boxes shall be used to raise the run of conduit to between the top and bottom reinforcing. Galvanised draw wires or other approved types shall be provided where conduits are not to be wired on completion or are to be wired by others.

All draw boxes and junction boxes shall be of ample size to permit the cables being drawn in and out. They shall be made of malleable iron or PVC approved type and the jointing surface machined to ensure a dust tight joint. All circular boxes shall be provided with long spouts

internally threaded incorporating a shoulder for the proper butting of the conduit and a solid brass earth terminal tapped and screwed into the base of the box.

All conduit boxes shall be screwed on or in walls, ceilings etc. by countersunk wood screws of appropriate size. Holes in boxes shall be adequately countersunk to ensure the complete recession of the fixing screws. All inspection and draw-in boxes shall be provided with covers fixed by round head brass screws.

Where surface conduit is specified, it shall be fixed by means of distance saddles and shall terminate in raised back pattern conduit boxes. Surface conduits shall not be bent or set to enter accessories, and where they turn through walls back outlet boxes shall be provided. Conduits shall be fixed at 1200 mm centres on vertical runs and 900 mm apart on horizontal runs.

Vertical conduit runs shall have saddles at 300 mm maximum from their points of emergence from floors or ceilings and the remaining saddles shall be fixed consistent with the requirements of spacing and appearance. Saddles shall be fixed on each side of every bend at 300 mm maximum from the point of intersection of the centre line conduit.

Conduits in ceiling cavities shall be supported independent of the suspended ceiling.

Where conduits cross expansion joints, the Contractor shall allow for the installation of expansion couplers at the positions of the expansion joint and at fight angles to it. He shall provide a bonding earth wire between each terminal fitted in the nearest conduit box each side of the coupler.

All flexible metallic tubing shall be galvanised watertight pattern fitted with sweated brass adaptors. External earth conductors, wrapped around the tubing, shall be provided.

Where conduits are laid in slab floor etc., the Contractor shall arrange for a competent person to be in attendance whilst the concrete pouting or screeding operation is being carried out, in order to avoid damage being caused to the conduits and also to ensure that the conduit work is in sound condition, properly and efficiently maintained during this installation period.

Particular care should be taken when setting out conduit runs to outlet points where they are to be fitted to furniture, kitchen fittings, etc. The Contractor shall ascertain exact details of the furniture and fittings construction in order that all conduit work shall wherever possible be concealed.

Conduits installed in chases of walls and floors shall be firmly secured by wrought iron pipe hooks or crampets and these fixings shall in themselves be sufficient to hold the conduits in place. Conduits installed in chases shall be painted with one coat of bitumastic paint before erection and a further coat shall be applied to all accessible surfaces including the hooks and the crampets after erection.

Recessed conduits buried in plaster shall permit a full 6mm. depth of cover over its entire length.

Provision shall be made for the tapping of condensed moisture.

Care shall be taken to prevent water, dirt or rubbish entering the conduit system during erection. Screwed metal caps or plugs shall be used for protecting open ends.

All conduit systems shall be erected completely with all conduit accessories connected. They shall then be offered for inspection and approval by the Engineer before any cables are installed. Conduit boxes shall be fixed to the structure of the building independently of the conduit.

Where a conduit is exposed to different temperatures (either by surrounding air conditions or by virtue of the surrounding medium with which it is in contact) at any particular time, the section of the conduit at the higher temperature shall be isolated from the section at the lower temperature by means of a conduit box filled with an approved permanently plastic compound, after completion and testing of all wiring. Such a condition would arise if a conduit running in a warmed building is run to exterior points.

Where galvanised conduit is specified, all conduit, accessories, switch boxes and all associated apparatus used in the installation must also be galvanised. Galvanised conduit shall be used when mounted outside a building, installed in floor chases subject to dampness or accidental flooding, or buried in the ground. Conduit systems shall be weatherproof when erected outside a building. Exposed conduit threads shall be given a coat of zinc rich paint.

Conduit buried in the ground shall be wrapped with PVC self-adhesive tape half lapped. The taping shall be extended for a distance of 150 mm beyond the point where the conduit emerges from the ground. Joints in galvanised conduit systems shall be made watertight using lead, aluminiurn paint and hemp and/or gaskets. The joints shall be partially screwed up before the paint and hemp are applied to maintain continuity.

All adaptable boxes shall be grey iron pattern unless otherwise specified. Where adaptable boxes are fitted flush, the cover plates shall be heavy gauge metal with 12 mm overlap on all sides. The internal depth of a box shall be not less than 40 mm.

Covers shall be secured by a screw at each comer and by additional screws as necessary to provide a maximum spacing of 300 mm between adjacent screws. Fixing screws shall be brass (round or cheese head).

Covers for boxes shall be of the same material as the box. For boxes mounted in weatherproof situations, the cover shall have a machined surface around the perimeter mating with a similar machined surface on the box and shall be complete with a gasket.

Every flush outlet box to which a luminaire pull cord switch or similar is to be fitted, shall be equipped with an approved type of break joint ring.

12.14 CABLE TRUNKING

Where trunking is specified it shall be constructed of 1.65 mm minimum thickness zinc coated mild steel or PVC and shall have a removable cover throughout its length with centre screw latch fixings. Trunking shall be rigidly fixed and supplied complete with purpose manufactured fittings, connectors, dividers, flanges, cable retaining clips, racks and copper earth continuity links. As an alternative, if approved, a proprietary brand of heavy duty plastic trunking may be acceptable. When submitting details for approval, full installation instructions as recommended by the manufacturer shall be included in the details.

All cables installed in trunking shall be labelled and identified in an approved manner. Clips shall be at 600 mm centres. Vertical cable trunking shall be fitted with cable pin racks arranged to avoid any strain on the cables.

All trunking shall be rust proofed, primed and painted and fixed at intervals not greater than 1,000 mm.

12.15 CABLE TRAYS

Cable trays, where required as part of the Contract supply, are to be the perforated galvanised sheet type.

Trays are to have upturned edges and be of a width suitable for the number of cables to be supported and are to be supplied with purpose- made galvanised steel brackets suitable for mounting from the building structure. External cable trays shall be provided with covers.

Where site cutting of trays or support bracket steelwork is unavoidable, recutting bare steel shall be protected with two coats of an approved zinc rich paint immediately after cutting.

12.16 CABLE JOINTING

The Contractor shall be responsible for the sealing and jointing of all cables supplied and installed as part of this Section of the Contract. Straight jointing of cables is not permitted without the written consent of the Engineer.

12.17 CONTACTORS

Contactors shall comply with BS 5424 or equivalent and shall be of the electrically held-in types contained in heavy gauge sheet steel cases suitable for panel mounting. Each contactor shall be continuously rated and suitable for thirty inductive switching operations per hour.

12.18 SWITCHES AND PUSHBUTTONS

Switches shall be rated for 15 amps, shall be single pole types and be provided with an earth terminal.

Switches shall be one way, two-way or intermediate as required and, where mounted together, they shall be fitted in a common box.

Switches for use in areas designated for surface installation shall be quick-make-quick-break fixed grid industrial types mounted in galvanised malleable iron boxes with protected dolly and arranged where necessary for multigang switching.

Switches for use in areas designated for flush installation shall be micro-break types fixed to white plastic cover plates and mounted in galvanised steel flush type boxes.

Switch-boxes shall be galvanised and fitted with screwed stainless steel front plates having a 6 mm overlap minimum for flush installations. They shall be suitably barriered and labelled where two phases are connected in the same box.

Switches mounted externally shall be of weatherproof pattern to IP55 level fitted with machined box and cover joint, brass operating handles, neoprene weathertight seals and external fixing feet.

Where DC emergency lighting circuits are to be switched, double-pole quick make, quick break switches with pillar type terminals and earthing straps shall be provided.

Switches shall be mounted 1.4 m above finished floor level.

Pushbutton switches shall either be flush or surface types contained in galvanised steel boxes and be single pole rated for 5 Amps. Pushbuttons shall be made of non-hygroscopic material, be non-swelling and so fitted as to avoid any possibility of sticking.

The terminals for all switches shall be adequate to accommodate 2 conductors, each a minimum of 1.5 mm^2 in area.

12.19 LIGHTING FITTINGS

Illustrations and/or samples of all lighting fittings which the Contractor proposes to purchase shall be submitted to the Engineer for approval before issuing any sub-orders.

Lighting fittings for interior and exterior use are to be manufactured and tested in accordance with the appropriate sections of BS 4533, IEC 60162 or equivalent and together with all components are to be suitable for service and operation in the tropical climate stated.

Each fitting is to be complete with all lampholders, control gear, internal wiring, fused terminal block, earth terminal and reflectors or diffusers as specified. The design of each fitting is to be such as to minimise the effect of glare and such that the ingress of dust, flies and insects is prevented, where open type fittings are used it is to be impossible for insects to become lodged therein.

The control gear for use with fluorescent lamps is to be quick or resonant start type without starters. Chokes are to be impregnated and solidly filled with polyester resin, or other approved high melting compound, are to be manufactured to restrict the third harmonic content to less than 17% of the uncorrected current value, and are to be silent in operation.

The built-in ballast units shall comply with IEC 60082 and shall include radio interference suppressors and capacitors to correct the fitting power factor to a minimum of 0.85 lagging. Control gear noise levels shall be minimal.

Fittings shall be supplied complete with closed end vitreous enameled metal reflectors or totally enclosed opal plastic diffusers, which shall be fully interchangeable.

Dispersive reflector fittings suitable for mercury bulb fluorescent or tungsten filament lamps shall be of heavy gauge sheet steel finished vitreous enamel. They shall be fitted with anti-vibrators and arranged for conduit box mounting, direct or pendant, on galvanised ball and socket dome type lids.

Bulkhead fittings shall have cast bases tapped for conduit entry, hinged bezels, heat resisting prismatic glasses fitted with neoprene gaskets and porcelain lampholders. Circuit cable shall not be connected direct to bulkhead fittings but shall terminate in a fixed base connector mounted in a conduit box adjacent to the fitting. Final connections to each fitting shall be carried out with silicone rubber covered cable. All bulkhead fittings shall be watertight pattern.

LED flood light fittings shall be explosion-proof, featured with high strength,impact resistance anticorrosion with performances of strong waterproof and dustproof ,body material shall be aluminium alloy.

Internal connections are to comprise stranded conductors not less than 0.75 MM2 covered with heat resistant insulation to the requirements of BS 6500 or equivalent. All internal wiring is to be adequately cleated to the fitting casing with an approved form of cleat. The finish of fittings for interior use is to be impervious to deterioration by atmospheric reaction. Fittings for exterior use shall have a vitreous enamel, natural aluminium or galvanised finish according to the manufacturer's standard product.

Lampholders for tungsten lamps up to 150 watts shall be brass or porcelain BC type and for higher ratings shall be ES or GES type according to size. Fittings for housing tungsten lamps exceeding 150 watts rating are to be provided with an approved method of dissipating heat from the lamp cap and terminal housing.

Lampholders as applicable are to be suitable for the lamp specified.

Lighting fittings are to be of the type description as generally set out in the schedule appended to this section of the Specification. The type references used are to be repeated in the Schedules and on the drawings.

12.20 LAMPS

The Contract includes the supply and erection of all lamps and tubes necessary to complete the installation.
Fluorescent lamps shall be manufactured and tested in accordance with BS1853, IEC 60081 or equivalent, shall be bi-pin types and shall have colour rendering values of X = 0.335 and Y= 0.342 (i.e., Colour 2) on the CIE chromaticity scale.

Tungsten lamps shall be manufactured and tested in accordance with BS 161 or equivalent and shall be bayonet cap for lamps up to and including 100 watts. Lamps rated for 150 watts and higher shall have edison screw caps. Low wattage lamps used in exit signs and emergency lighting units may be small or miniature edison screw.
Discharge lamps shall be manufactured and tested in accordance with BS 3677 or equivalent. Mercury vapour lamps shall be fluorescent types having a 10% red ratio colour correction, whenever used.

LED flood light shall be rain/fog penetrable and tested in accordance with IEC/EN 62471 or equivalent.

12.21 SOCKET OUTLETS AND FUSED SPUR OUTLETS

Each socket outlet shall comply with the requirements of the BS 1363 or equivalent and shall be the interlocked shuttered and switched types arranged for surface or flush mounting in single or multi- gang units as appropriate.

Each fused spur outlet shall be equipped with double pole isolator, a fuse to BS 1362 or equivalent and where required front entry for flexible connection.

Each socket outlet and fused spur outlet shall be equipped with a galvanised metal box with earth terminal.

Each group of five socket outlets is to be provided with a matching fused plug top.

All socket outlets for exterior use shall be galvanised and weather- proof and be equipped with screwed dust proofed cap attached to the socket by means of a chain.

12.22 TIME SWITCHES

Time switches for use with lighting systems shall be the synchronous motor wound types protected by a suitably rated fuse for 230 volts operation with a nine hour reserve spring and are to be fitted with a twenty-four hour hand set dial, two "off" and two "on" levers and manual operation pushbutton. The main contacts shall be rated for 20 Amps on a 230 Volt 50 Hz AC supply.

Time switches shall be suitable for mounting in the distribution boards supplying the circuits to be controlled.

12.23 POLES

Lighting poles shall be tapered, of hot dip galvanised steel with bituminous preservative inside and outside at the base and shall be approved by the Engineer.

Each pole shall be equipped with a base section compartment of 470 mm by 150 mm to house an inspection trap, lockable door, fused cutout, cable entry and terminations for both the incoming and outgoing power cables and secondary cables feeding the light sources.

Poles for substation lighting shall support the floodlights at 11m above ground level and poles for access roadway lights shall support the lanterns at 4.5m above ground level.

The Contractor shall ensure each pole is provided with foundations suitable for the ground conditions occurring at each Site.

12.24 INTERIOR INSTALLATIONS

Wiring for the lighting and socket outlet installations shall comprise PVC cables drawn into conduits attached to walls, structural or roof steelwork or ceilings as appropriate. (See Clauses 12.13 & 12.14).

Surface and flush type installations are required according to the particular area as indicated in the schedule appended to this section.

In areas where flush type installations are indicated the wiring shall be drawn into conduits buried under wall finishes or concealed above ceilings as appropriate.

All fixings shall be of a type approved by the Engineer and all metalwork used shall be galvanised. Fixings to structural steelwork shall be with purpose made brackets or clamps; the drilling of structural steelwork will not be permitted.

Cleats with two screw fixings shall be used for supporting conduits at not greater than 2m intervals.

All switchboxes, socket outlet boxes and items of a similar type shall be fixed with two screws or bolts.

Switches and pushbuttons for lighting circuits shall be mounted at 1400 mm above finished floor level. Socket outlets shall be mounted 500 m above finished floor level but those for use with workshop benches shall be mounted 150 mm clear of the bench working surface.

Lighting fittings shall be attached to ceilings, walls, trunking or roof steelwork or suspended therefrom as appropriate.

Where fittings are to be suspended, rod type suspension units shall be employed.

Final connections to all suspended lighting fittings shall be with heat resistant flexible cable terminated in porcelain clad connectors in the ceiling or junction box which shall also terminate the main circuit cable. The cable length shall be such that the suspension unit supports the full weight of the lighting fittings.

Where recessed type lighting fittings are to be installed suspension units shall be used to prevent the weight of the fittings being applied to the suspended ceiling. It shall be possible to carry out maintenance from the underside of the fitting without disturbing the false ceiling. To facilitate this need the final connection to each fitting shall be with heat resistant flexible cable from a plug in type ceiling rose mounted above the false ceiling.

All cables not contained within conduit for their whole route shall be terminated with a cable gland.

Where lighting fittings are mounted direct on walls or ceilings, the main circuit cables may be connected into the fitting terminal block. Where terminal blocks do not exist within the lighting fitting, flexible heat resistant cable shall be used connected to a separate junction box.

Earth continuity shall be maintained throughout the entire wiring installation with separate insulated earth continuity conductors of adequate cross-section ultimately connected to a common earth terminal at the respective distribution board.

Within the interior installation adequate provision shall be made for connection to small ventilating fans, which are not energised from the central air conditioning control and starter panel.

Each and every trunking route shall be bonded across all joints with external copper bonding links supplied for the purpose.

12.25 EXTERIOR INSTALLATION

Exterior substation lighting fittings shall be attached to substation walls at high level or pole mounted as appropriate. Security lighting round the perimeter wall/fence is to be provided.

When locating the floodlights for the switchyard lighting, the Contractor shall ensure that all floodlights are outside safety clearance for the high voltage switchgear at the particular location.

Cables to exterior lighting shall be laid direct in ground, laid in concrete trenches or cleated to buildings structures as appropriate to the route requirement. The cables shall be terminated at a cut-out located at the base of each support. Wiring between the cut-out and the control gear or lantern shall be with multicore cable run within poles or with cable drawn into galvanised steel conduit attached to the supporting structure.

12.26 EMERGENCY LIGHTING

Emergency lighting shall comprise lighting fittings of the types indicated in the schedule appended to this section of the Specification.

The system shall be so arranged that on failure of the normal a.c. supplies to the lighting installation the emergency lighting system will automatically be switched on. Other than those of the "on demand" type, all emergency lighting shall be switched "off" 5 minutes after restoration of normal supplies. Each emergency lighting unit shall have a minimum 3 hour rating.

Sufficient fittings of Type E3 shall be provided in each room to enable the rooms and building to be evacuated safely.

In addition, in designated working areas emergency manually switched lighting, to give not less than 30 lux, shall be provided utilising type E4 fittings. Switches shall be labelled to the approval of the Engineer.

The security lighting scheme shall illuminate the area to 6 metres inside the perimeter wall to the lighting level specified.

12.27 TELEPHONE SYSTEM

A complete conduit/duct system shall be provided throughout the building to enable the telephone cables to be run to the proposed extension points. This includes telephone wiring to operators' desks and office in the control building.

Telephone instruments, the PABX and connections to PTT exchange lines shall be carried out by other Contractor.

12.28 SCHEDULE OF LIGHTING FITTINGS AND SOCKET OUTLETS

All lighting schemes are to utilise fittings and lamp types which are available locally in Bangladesh to ensure that replacements are readily acceptable.

Lighting fittings described in this Schedule shall also meet the general requirements of the Clause for Lighting Fittings of this Specification.

TYPE F1 Shall indicate a basic channel complete with control gear and lampholders for one fluorescent lamp, equipped with an open ended metal reflector having upward light slots.

TYPE F2 Shall indicate a fitting which shall comply generally with the description for Type Fl but be equipped for use with two lamps.

TYPE F3 Shall indicate a recessed modular fitting suitable for mounting in a suspended ceiling and equipped with a clear prismatic controller. The metalwork and trim are to comprise a rigid welded unit so arranged as to be invisible when erected complete with controller. The fitting is to be equipped with a pre-wired removable gear tray and adjusting facilities to enable levelling relative to the ceiling to be carried out after erection. The assembly is to be complete with control gear and lampholders for one 1500 mm long 65 watt fluorescent lamp.

TYPE F4 Shall indicate a fitting which shall generally comply with the description F3 but with an open type grid diffuser.

TYPE F5 Shall indicate a dust-tight, weatherproof and vapour resistant fitting, having a grey polyester fibre glass reinforced chassis containing the control gear and having lampholders for one 1500 fluorescent lamp. The fitting shall be complete with a vacuum formed acrylic diffuser which is secured to the body with injection moulded toggles and sealed with a neoprene gasket.

TYPE F6 Shall indicate a weatherproof bulkhead fitting with a cast aluminium base and vandal resistant diffuser equipped with control gear and lampholders for two fluorescent lamps.

TYPE E1 Shall indicate a self-contained, self-sustained (normally off) emergency lighting unit, complete with integral batteries and control gear, with the words "EXIT" in white letters on red background in English and Arabic. It shall be energised from the batteries under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

TYPE E2 Shall indicate a self-contained, self-sustained (normally off) wall mounted emergency lighting unit comprising a pilot light and two 100 watt spotlights complete with integral batteries and control gear. The pilot light shall be energised under mains failure conditions with manual "on demand" switches for the spotlights. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

TYPE E3 Shall indicate a self-contained, self-sustained (normally off) wall or ceiling mounted emergency lighting unit complete with integral batteries and control gear. The lamps shall be energised under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

TYPE E4 Shall indicate a 110V DC wall or ceiling mounted emergency lighting unit which shall be manually switched and be similar to type E3.

TYPE H1 Shall indicate forward throw floodlight fitting comprising a sheet steel vitreous enamelled or spun aluminium reflector housing a 500 Watt Halogen lamp. The fittings to be complete with wall mounting bracket.

TYPE H2 Shall indicate a semi cut-off roadway and perimeter security lantern with housing manufactured from a one piece LM6 aluminium alloy casting enamelled white internally and equipped with reflector bowl of heat resisting glass, all suitable for housing the lampholder and control gear for one 150 Watt sodium vapour lamp. The fitting to be equipped with pole arm suitable to give an outreach of 1 metre.

TYPE S1 Shall indicate a 13 Amp single or double gang flush mounted switched socket outlet.

TYPE S2 Shall indicate a 13 Amp single or double gang surface mounted switched socket outlet.

TYPE S3 Shall indicate an ironclad one gang heavy duty 4 pole interlocked switched socket outlet with scraping earth connection suitable for use on a 400V 3 phase 4 wire 50 Hz for 125A. Each socket is to be supplied complete with cable box with 2 glands, suitable for terminating a PVCWPVC cable and shall be fitted with a screwed dustproof cap attached to the top of the socket by means of a chain. Matching plugs to be provided in each socket.

TYPES4 Shall indicate a 15 amp 3 phase 4 wire switched socket outlet with plug flush mounted.

12.29 SCHEDULE OF LIGHTING REQUIREMENTS

12.29.1 Control Building

Location	Service Illuminance (Lux)	Glare Index
(a) Control Relay Room	400	25
(b) Behind panels	100	-
(c) Office	500	20
(d) Battery Room	100	-
(e) Toilet	100	-
(f) Corridors, Stairs	100	20

12.29.2 Outdoor Areas

(a) Switchyard Floodlighting	20	-
(b) Transformer Compounds	120	-
(c) Roadway Lighting	20	-
(d) Perimeter Wall Security	10	-
(e) Control Building Exterior	15	-

12.30 AIR CONDITIONING AND VENTILATION

12.30.1 Scope of Work

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the heating and ventilating systems for the control building.

All heating and ventilating systems shall be fully automatic in operation and shall be capable of maintaining internal conditions within the bands of temperature and humidity specified hereafter. the substations are normally manned and allowance shall be made for at least four persons on site in the design.

12.30.3 Air Conditioning

The following areas shall be air conditioned.

Control/Relay room

Communication/SCADA/PLC room

Office/record room

Air conditioning shall be provided in the form of Air Cooled Split System Air Handling Units. The systems shall handle predominantly re circulated air with a controlled quantity of fresh air introduced either at each unit or independently via a separate supply and extract system. Supply air distribution ducts for the Control/Relay room shall be located in the false ceiling serving supply diffusers. Return (re circulated) air shall be drawn in through the front of each unit.

The cooling medium for the split System Air Handling Units shall be direct expansion provided by air cooled refrigeration condensing units located on the roof of the building or wall mounted on building exterior, and interconnected by refrigerant pipework to multi circuit direct expansion cooling coils.

Air conditioning system shall be thermostatically controlled to maintain internal conditions under continuous operation within the limits stated. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

12.30.4 Mechanical Ventilation

Supply and extract ventilation shall be provided to serve the following areas:-

Switchgear room

Battery Rooms

Toilets (Extract only)

Cable basement

Supply air handling plants shall consist of a sand trap fresh air intake louvre, insect screen, pre-filter, bag filter, electric air heater battery, fan and distribution ductwork.

The air intake shall not face the prevailing wind.

Extract ventilation shall be provided by means of wall mounting fans, roof extract units or ducted systems with louvred discharges to atmosphere. Individual extract fans shall be provided for Battery room and toilets.

Extract fans for battery room shall be corrosion resistant throughout , with a 4 mm PVC lining.

12.30.5 Basis for Design

(a) External Design Conditions

The external conditions for the calculation of duties for the mechnaical services shall be with mean monthly, maximum and minimum values as below:

Maximum ambient shade temperature		42 °C
Minimum ambient shade temperature		4 °C
Maximum daily average temperature		35 °C
Maximum annual temperature		25 °C
Relative humidity	- maximum	100%
	- minimum	80%
Solar radiation		100mW/sq.m

All plant and equipment installed externally, or which can be affected by external condition shall be capable of withstanding without damage or deterioration the effects of solar radiation, rain, wind, dust, sand storms or other weather phenomena prevalent in the area in which particular building is located.

(b) Internal Design Conditions

Air conditioning systems shall be capable of maintaining internal l conditions in all air conditioned areas within the following bands or, if necessary for the satisfactory operation of the equipment housed, more stringent requirements:

For substations	22+4 °C DB
	40 to 70% R.H.

The following air change rates/hour shall be provided in mechanically ventilated area:

Switchgear Rooms	10
Battery Rooms	10
Toilets	12 (Extract only)
Cable basement.	6
Other general areas	4

All air conditioning and ventilating systems shall be designed for continuous operation. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

The Contractor shall calculate heat gains and losses under the specified conditions for each part of each building, taking into account solar radiation, thermal transmittance through roofs, walls, floors and windows, fresh air requirements, heat emission from installed e1ectrical equipment and lighting, personnel, infiltration and any other sources. The Contractor shall be responsible for determining the heat transfer coefficients for all materials used in building construction. In the event of any change in materials. design or method of building construction, the Contractor shall at all times be responsible for rechecking the design of all systems to ensure that they are capable of meeting the specified design requirements

12.30.6 Air Cooled Condensing Units

The cooling medium for the air conditioning shall be direct expansion refrigeration provided by air cooled condensing units located externally.

The condensing units shall be of the fully packaged type requiring only site connection of refrigeration pipework, , isolated electrical supply and input from the control system.

The individual item of refrigerant equipment shall be matched such that the required performance of the evaporator is achieved concurrently with the satisfactory operation of the compressor and adequate heat rejection at the condenser. Each system as a whole shall maintain the correct duty at the design ambient and operate at the maximum ambient conditions stated without exceeding the safe operational limits of any individual item of equipment and without causing any safety device to operate.

All electrical equipment, control, magnetic coils and solenoids shall be manufactured specifically for operation at the electrical characteristics specified herein and such items designed for any other characteristics shall not be used.

Air cooled condensing units and air handling units that are inter-connected on site with refrigerant piping shall all be supplied by the same manufacturer.

The casings of the condensing unit shall be weatherproof and shall incorporate adequate access and inspection panels secured in place by rustproof fasteners.

The whole of the casing shall be treated for corrosion and weather resistance and ungalvanised mild steel shall not be used (even if painted).. The unit shall be finished in not less than two coats of weather resistant finish, such as baked enamel of a light reflective colour.

The access panels shall be adequately sized for the service and removal of all working parts of l the unit. All panels shall be stiffened and supported to prevent flexing and drumming.

Electrical equipment shall he contained in a fully weatherproofed enclosure with internal division between the power connections and equipment and the control connections and equipment.

12.30.7 Refrigeration Systems

(A) Liquid lines shall be insulated where they are in direct sunlight or where they pass though non-air conditioned areas.

Suction lines shall be insulated over their entire length.

All insulation to refrigeration pipework shall be flexible closed cell l foam phenolic rubber type with a temperature range of -40°C to +105°C and having a thermal conductivity of 0.0375 w/m °C at 2l °C and a water vapour transmission of less than 6.0 ng/Ns.

The thickness of insulation shall be in accordance with the following tables:-

i) Suction Lines

Location	Insulation thickness for O.D. Pipe Sizes Range	
	6-10mm	12-22mm
Exposed to weather	13mm	19mm
In air conditioned spaces	9mm	19mm
In non-air conditioned spaces	9mm	9mm

ii) Liquid Lines

Exposed to weather and in non-air conditioned spaces	9mm	9mm

(b) The refrigerant used shall conform to BS 4334 Group 1 or equivalent and shall be non explosive, non-combustive, non-toxic and non-irritating.

Packaged air conditioning plant items requiring interconnection with refrigeration piping on site shall be leak tested by the manufacturers and delivered to site with a holding charge of refrigerant.

12.30.8 Console Air Conditioning Units

Console model room air conditioners shall be of the slim-line pattern and complete with 4-way adjustable grilles, heavy gauge zinc coated stove enamelled sheet steel casing with single or two colour decorative finish. Electrical-heaters shall not be fitted.

The casing and position shall be such as to protrude not more than 250 mm into the air-conditioned space and no external projection beyond the building line will be permitted other than the fixing of the condenser cooling air grille.

The units shall be extremely quiet ill operation, the noise level not being higher than 30 dB. All sections of :he casing shall be acoustically and thermally insulated.

Compressors shall be of the fully hermetic type, fitted with resilient mountings and complete with thermal overload protection and starting relays.

Evaporators shall be manufactured of' copper tube with copper or aluminum fins mechanically bonded. The evaporator fan shall be of double inlet, double width type and complete with continuously rated totally enclosed electric motor.

Filters shall be of the washable type, suitably positioned for easy access for cleaning.

Automatic control by means of an integral thermostat shall be provided, together with the safety control to prevent excessive cooling.

Motors shall be air cooled and units shall be complete with internally mounted condenser cooling fans with totally enclosed motors.

Fresh air shall be introduced separately by means of a central fresh air plant, where these units are proposed to serve individual offices in a building.

Units shall be supplied as a whole and be suitable for easy removal and re-positioning should this be desired at a later date.

12.30.9 Ductwork

All sheet metal ducting shall be manufactured and installed in accordance with the Institution of Heating arid Ventilation Engineers Guide to Current Practice Section B 16, the American Society of Heating, Refrigeration and Air Conditioning Engineers, or the Heating and Ventilating Contractors Association of United Kingdom Specification DW/142 or equivalent international standards for sheet metal ductwork for low velocity low pressure air system with air velocity of up to 10 m/s.

Ail ductwork and fittings serving hazardous areas, such as battery rooms where corrosive fumes are expected, shall be of rigid PVC materials.

12.30.10 Condensate Drains

Provision shall be made for condensate to be passed into the rainwater drainage system. Condensate drains must be routed directly into the drainage system or individual soakaways. Pipes discharging onto substation or building brick paving will not be permitted.

12.30.11 Extract Ventilation Units

This clause covers fan powered extract ventilation units for mounting in walls and windows, on roofs and in plant rooms.

Extract units shall incorporate propeller. aerofoil, axial, centrifugal or hybrid type fans which shall be constructed in accordance with the relevant sections of this Specification.

Roof units shall comprise a galvanised sheet steel base suitable for use as a weathering skirt, a mild steel fan/motor mounting frame and a spun aluminium cowl.. The sheet steel base shall be constructed to support the fan/motor without distortion and where the fan is belt driven shall incorporate a rigid subframe for motor mounting. Fans shall be diaphragm mounted or fitted with a cylindrical casing designed for removal from the unit from inside or outside the building without disturbing the weathering skirt or cowl fixings. The cowl shall be weatherproofed and shall be hinge mounted to provide complete access to the fad/motor.

Lubricating points shall be extended to a convenient access point.

Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

12.30.12 Air Filters

All filter media hall be properly bonded and protected against filter fibre or particle migration. The direction of air flow shall be clearly marked on all filter panels and on installation frames.

Access to filters shall be through removal panels fitted with quick release fasteners and rubber sealing gaskets.

Each disposable panel filter system shall be provided with 4 complete spare sets for use during the commissioning period. These sets shall be in addition to any filter cells supplied as spares in accordance wit11 the general clauses of this specifications.

Filter performance shall, unless otherwise noted, be taken to mean the Overall Gravometric Efficiency against BS 6540:Part I Duct Test or equivalent.

Filter media of all types and sizes shall be supported in rigid peripheral frames with internal or external wire support of the media to ensure that the media shall not collapse under air flow. The holding frames shall incorporate accurately sized channel sections to provide a good fitting for the filters.

The type of washable and/or disposal panel filters shall be subject to the Engineer's approval.

12.30.13 Grilles and Louvres

Grilles shall be of aluminum construction and shall be fixed by means of subframe with spring clips or screw fixings.

The corners of front flanges of grilles and subframes shall be mitred and jointed to produce a clean unbroken appearance and visible aluminum sections shall be free from extrusion marks.

Front flanges shall be at least 30mm wide and shall incorporate a lip of at least 4.5 mm and a felt gasket. Blades shall be fixed at even centers with intermediate mullions giving support for blades of more than 550 mm long. Grille finish shall be anodised natural aluminium colour except where otherwise indicated.

All grilles shall be fitted with an opened blade damper for regulation purposes and shall be fitted with acoustically lined inlet plenums where necessary in order to comply with the acoustic limits of this Specification.

Outdoor air louvres shall be of all extruded aluminium construction fitted with opposed blade dampers in the connected ducting where necessary for air flow regulation, Movable blade louvres shall not be used.

Louvres shall be weatherproof and shall incorporate an aluminium wire mesh screen on the inside surface.

The dimensions of louvres for mounting in the building structure shall suit the concrete block or brick modules and shall be fixed to a hardwood frame.

12.30.14 Control Equipment

Each item of shall be provided with local isolation and/or emergency stop buttons to facilitate maintenance, inspection and emergency operation.

The control system shall be of the electronic type, capable of providing the degree of thermostatic control specified. The Contractor shall provide full wiring diagram of all control circuits giving terminal connection reference.

The control system shall incorporate all necessary safety interlocks for the successful operation of the mechanical plant and system. All of the individual control elements shall be provided by the same manufacturer.

Temperature sensors shall be of the resistance type using nickel based elements and shall be accurate to $\pm$ 1oCover the range of 0 ^{o}C to 30 ^{o}C. The sensor resistance shall be compatible with the measuring bridge of the matching control box.

12.30.15 Electrical Connections

All electrical power control cables and wiring associated with the air conditioning and ventilation systems, including all connections between control panels, valves, thermostats, sensing probes and other like items shall be supplied, installed and connected up as part of this Contract.

The cabling and wiring system shall comply with the requirements of the relevant clauses of this Specification and be either surface or flush installation as appropriate.

Cables and wiring shall comprise either PVCWPVC laid in cleats or trenches, or PVC drawn into galvanised conduits and trunking.

Final connections to electric motors and all other items of plant subject to movement and vibration shall comprise flexible cable in flexible conduit.

12.30.16 Manufacturers

Wherever possible all air conditioning and ventilating plant shall be selected from a single manufacturer's product range and origin. Where this is not possible, because of practical or technical constraints. then the number of different sources of origin shall. be kept to a minimurn. Local service facilities shall be available for the equipment proposed.

The Contractor shall provide, with his submission, illustrated technical literature covering all plant and equipment offered.

12.30.17 Standards

All air conditioning and ventilation equipment shall conform to British Standards, Chartered Institution of Building Services or ASHRAE recommendations or other recognised International Standards.

12.30.18 Approval

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the selection of all air conditioning and ventilating plant, plant selection details and full working drawings. Such approval shall not relieve the Contractor of his contractual responsibilities.

12.30.19 Maintenance

The Contractor shall be responsible for the maintenance of all installations covered by this section of the Specifications for the period stated elsewhere in the Specification.

12.31 EARTHING AND BONDING

All equipment being supplied under this Section shall be effectively bonded to ensure earth continuity throughout the system. Continuity may be provided by means of cable armouring but a separate earth continuity conductor shall be included with all wiring in conduits. No reliance shall be placed on metal to metal joints in conduits for earth continuity. The earth continuity conductors shall as far as possible be in one continuous length to the furthest part of the installation from the controlling switchboard. The earth conductor shall connect all metal cases housing electrical equipment. The branches shall be connected to the main conductor by permanently soldered on mechanically clamped joints.

12.32 TESTING AND COMMISSIONING

The Contractor shall be required to prove that the installed system meets the design requirements and Specification to the satisfaction of the Engineer.

SECTION 13

FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND PROTECTION

TABLE OF CLAUSES

SECTION 13

FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND PROTECTION

13.1 SCOPE

This specification describes the communication requirements for the transport of voice, data and protection signals between the new substations with existing substations and the National Load Dispatching Centre (NLDC) in Rampura, including engineering, configuration, testing, installation, commissioning and training.

Drawing in this Specification shows the planned arrangements of fibre optic multiplexer equipment for communication and protection. 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.

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, ma-terial and services shall be included in the contract price.

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 multi-plexer equipment for communication and protection to be supplied under this project shall consist of equipment which can totally be integrated into the existing telecommunication system in PGCB's net-work, 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 or GE (former Alstom) or ZTE or Huawei equivalent make. Since, some of the above mentioned make (i.e. ABB or GE (former Alstom) or ZTE or Huawei) Telecommunication System is already in PGCB’s System and their performance is proven. Only Manufacturer Authorization among the Qualification Criteria of sub-clause 2.5 of Section 3 of volume 1 of 3 of the Bid Document, is required to be submitted with the bid of the bidders who chose to propose Telecommunication System from these proven manufacturers. Acceptance of any other Telecommunication System (except PGCB’s approved Vendor make) with similar characteristics shall have to fulfill the Qualification Criteria of sub-clause 2.5 of Section 3 of volume 1 of 3 of the Bid Document.

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13.2 Summary of Standards

The Equipment shall comply with the latest ITU-T recommendations for the plesiochronuous and synchronuous hierarchies.

The equipment shall be independent type tested.

In particular the mentioned recommendations shall be covered:

13.2.1 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, 6313, 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.711: Pulse code modulation (PCM) of voice frequencies
- ITU-T G.712: Transmission performance characteristics of pulse code modulation channels
- ITU-T G.732: General aspects of digital transmission systems – Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s
- ITU-T G.735: Characteristics of primary multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
- ITU-T G.736: General aspects of digital transmission - Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s
- ITU-T G.737: Characteristics of external access equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
- ITU-T G.823: The control of jitter and wander within digital networks, which are based on the 2048 kbit/s hierarchy
- ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

13.2.2 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 V1.1.2: Generic Processes and Performance
- ETS 300 417-2-1 / EN 300 417-2-1 V1.1.2: SDH and PDH Physical Section Layer Functions

- ETS 300 417-3-1 / EN 300 417-3-1 V1.1.2 : STM-N Regenerator & Multiplex Section Layer Functions
- ETS 300 417-4-1 / EN 300 417-4-1 V1.1.2 : 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

13.2.3 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 V1.1.2: Synchronisation Layer Functions
- ETS 300 462-1 / EN 300 462-1-1 V1.1.1: 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 Synchronuous Digital Hierarchy (SDH) and Plesiochronuous 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)

13.3 Abbreviations

ADM	Add-drop multiplexed
ALS	Automatic Laser Shutdown
BIP	Bit Interleaved Parity
CAS	Channel Associated Signalling
CAP	Carrier-less Amplitude and Phase
CRC	Cyclic Redundancy Check
DTMF	Dual Tone Multi-Frequency
EN	European Norm
EOW	Engineering Order Wire
ETS	European Telecommunications Standards
GPS	Global
HDSL	High Density Subscriber Line
IEC	International Electrical Commission
ITU	International Telecommunication Union
IP	Internet Protocol
ISDN	Integrated Services Digital Network
MCMI	Multi Coded Mark Inversion
MS	Multiplex Section
NE	Network Element
NMS	Network Management System
LAN	Local Area Network
OS	Optical Section
OSPF	Open Shortest Path First
PDH	Plesiochronuous Digital Hierarchy
PPP	Point-to-Point Protocol
RS	Regenerator Section
SDH	Synchronuous 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

13.4 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 2 Mbit/s and 8 Mbit/s electrical interfaces complying with ITU-T recommendations G.703 / G.704 and 2 Mbit/s HDSL interfaces shall be available. In addition, optical STM-4 aggregate interfaces on 620 Mbit/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 2 Mbit/s streams. Path protection on 64 kbit/s and 2 Mbit/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, tele protection 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
- 4-wire E&M voice interface
- G.703, 64 kbit/s data Interface
- X.24/V.11 (RS-422), Nx 64 kbit/s data interface
- Alarm collection interface
- Teleprotection command interface
- Binary signal (status and control) interface
- 2 Mbit/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 (620 Mbit/s) optical 1+1 interface for medium and long distances, with automatic laser shut down.

- STM-4 (620 Mbit/s) optical add-drop interface for medium and long distances, with automatic laser shut down
- STM-4 (620 Mbit/s) electrical interface
- 2 Mbit/s HDSL interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

13.5 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-4 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 shelf.

13.5.1 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 40x2 Mbit/s, or 200x64 kbit/s non-blocking.

13.5.2 Redundant centralised functions

The equipment shall be equipped with redundant circuits for all centralised functions.

13.5.3 Power Supply

The multiplex equipment shall operate at 48 VDC +/- 15%. Redundant power-supply shall be supported.

13.5.4 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

13.5.5 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.

13.5.6 Ambient Conditions

Storage and transport: -40 ... +70°C; 98% (no condensation)
Operation: -5 ... +45 °C, humidity of max. 95% (no condensation)

13.5.7 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.

13.5.8 Network management system

The equipment shall be software programmable, either by a local craft terminal - preferably notebook - or 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 the PDH and SDH network.

13.5.9 1+1 Path protection

The equipment shall provide means to protect 64 kBit/s 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.

13.5.10 1+1 Section protection

The equipment shall provide means to protect 8 Mbit/s and 155 Mbit/s connections. 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.

13.5.11 Network Topology

It shall be possible to build point to point - , linear-, ring-, T, and meshed networks.

13.5.12 Synchronisation

The equipment shall be synchronisable with an external 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.

13.5.13 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.

13.5.14 Test Loops

The equipment shall provide means to loop signals on 64 kBit/s level as well as on 2 Mbit/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.

13.5.15 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.

13.6 Requirements for Transport Level

13.6.1 SDH Aggregate Units

The interface shall be designed for use on single mode fiber at 1310nm and 1550nm. The optical connectors shall be E2000.

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:

6 × STM 4 optical port interface
4 × STM 1optical port interface
2× STM 4 electrical port interface
2× STM 1 electrical port interface

13.6.2 HDSL Aggregate Units

2 Mbit/s HDSL interface

The HDSL interface shall provide means to interconnect the multiplexer over two pairs of copper wire up to 12 km 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.

2 Mbit/s HDSL Desktop Terminal

This Terminal shall provide a HDSL interface to transmit 2 Mbit/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, 2 Mbit/s, 75 ohm
- G.703, 2Mbit/s, 120 ohm
- X.21/V11, Nx 64 kBit/s (N = 1 .. 32)
- V.35, Nx 64 kBit/s (N = 1 .. 32)
- V.36 / RS449, Nx64 kBit/s (N = 1 .. 32)

LAN connection:

10/100 BaseT 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 2 Mbit/s link over two pairs of copper.

HDSL Repeater:

An HDSL repeater solution for distances longer than 12 km shall be offered including a remote powering solution.

HDSL Line Protection:

The HDSL equipment shall (where necessary) be protected against influences of induced voltages up to 10 kV.

13.7 Tributary Units

13.7.1 4-Wire Interface (VF interface)

This interface shall provide 8 voice channels with a bandwidth of 300 Hz .. 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 .. -16 dBr
Output:+7.0 .. -16 dBr

Modules where each interface can be individually configured with 1+1 path protection shall be available.

13.7.2 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 20 Hz, 25 Hz, and 50 Hz.

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

13.7.3 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 .. +4 dBr
output voice level –7.5 .. –1 dBr
metering pulse enable/disable
signalling bit definition
loop back of voice to the telephone

13.7.4 Partyline 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 inband DTMF signalling to call another EOW-Terminal. The Terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (1..4 digits), and two group call numbers (1..4 digits each).

13.7.5 V. 24/V.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.

13.7.6 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.

13.7.7 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.

13.7.8 V.36 / RS 449 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.

13.7.9 64 kBit/s Codirectional Interface

This interface shall comply with the ITU-T G.703 part 1.2.1 for codirectional 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.

13.7.10 LAN Interface

There shall be a 10/100 BaseT interface available with Router Bridge and FRAD Function available. The following specification shall be covered:

Ethernet connection: 10/100 BaseT
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 Nx64 kBit/s and 2 Mbit/s.

13.7.11 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.

13.7.12 Teleprotection Interface

The protection of the 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.

Tecnnical Requirements:

This interface shall provide means to transmit four bi-directional command channels.
The signals shall be adjustable from 24 to 250 VDC 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.

13.7.13 Optical Protection Relays Interface

This interface shall have an optical port to connect protection relays for teleprotection to the multiplexer. It shall operate on 1300 nm use MCMI line coding and be suitable for teleprotection relays.

13.7.14 Optical amplifier

In case of long distance communication, which can not be covered by standard a optical interface, optical amplifier shall be applied.
The amplifier shall

- provide a power budget of at least 48 dB
- for bit rates from 8 Mbit/s up to 622 Mbit/s
- on a pair of single-mode fibre
- for single wavelength (single channel)
- have no dispersion limits for STM-4 applications up to 250 km.

13.7.15 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 .. 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.

13.7.16 2 Mbit/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 2 Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals.

13.8 TELEPHONE SYSTEM

There are two separate telephone systems under NLDC, that is, Operational Telephone System (IP based) and Administrative Telephone System (Traditional circuit switch based).

13.8.1 OPERATIONAL TELEPHONE SYSTEM

An IP Phone facility shall be provided at each new substation. For Comilla(S) and Madhunaghat GIS substation existing communication system including telephone system facilities shall have to be transfered to new GIS building. 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 telephone sets proper to the above-mentioned Administrative Telephone System shall be provided at each new substation.

The contractor shall consult the Employer and confirm whether more additional telephone sets/instruments for the systems need to be provided including their types and specifications.

13.8.2 Remote Subscriber

Facility for minimum 10X2W of remote subscriber shall be provided and installed at the substation and the remote sbscribers shall be connect with the neasrest exisitng exchange of the exisitng telephone network. Necessary cards required at nearest exchange and its asscociated muliplexter shall be included in the contract price.

13.8.3 Integration with Exsiting System

The trunk numbering plan shall be compatible with the present scheme in service in Bangladesh. The telephone signalling (dialling) system shall be compatible with the present system.

An alarm system shall be provided to indicate traffic failure including blown fuses, loss of power supplies etc. In addition, contacts shall be provided to facilitate extension of the alarms to the telecontrol equipment.

13.9 COMMUNICATIONS DC POWER SUPPLY EQUIPMENT

13.9.1 General

(a) Basis of Design

The equipment shall comply with IEC 146 and 478.

The charger shall be of either the thyristor controlled type or of the SMPS type. The battery shall be nickel cadmium type - as detailed in a separate section of this Specification.

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years, when operating under the specified service conditions.

(b) Operating Principle

The output of the charger shall, during normal operation, continuously supply the power requirements of the load whilst simultaneously maintaining the battery charge in the float charge mode. In the event of an interruption in the a.c. mains supply to the charger, the battery shall supply the load requirements for not less than the specified standby time - whilst maintaining the output voltage within permissible limits.

Upon restoration of the a.c. mains supply, the rectifier shall automatically resume supply of the load requirements whilst simultaneously recharging the battery at the float voltage.

13.9.2 Configuration

The power supply installation shall comprise two batteries and two charging sources. each charger shall be able to float charge both batteries as well as supplying the total load.

The total battery capacity shall be able to supply the total load (comprising the delivered load together with 20% spare for future use) for at least 10 hours in the event of failure of the a.c. mains supply.

The d.c. power supply equipment is required to limit the output voltage to the load within plus 15% and minus 15% of the nominal value, provided these values do not exceed the voltage guarantee of the load equipment. The power supply output positive shall be earthed.

13.9.3 Charger

(a) General

The charger shall operate according to the constant voltage current limiting principle and shall incorporate a soft start feature to gradually accept load on initial energising.

The charger shall restart automatically upon restoration of the a.c. mains supply following a mains supply interruption, and recharge the battery at the float voltage.

Internal cooling shall be by natural ventilation. Forced cooling is not acceptable.

The charger shall be suitable for operation in parallel with one or more chargers, and shall include a current sharing facility.

The charger shall be of sufficient output capacity for the application, parallel operation of chargers (where required) is for the purpose of redundancy and not to satisfy the output current requirements.

(b) Charger Output

The output characteristic shall provide an output voltage regulation of ±1%, over the specified a.c. mains voltage and frequency range and for load changes 0-100%. The output voltage regulator shall be adjustable within limits approved by the Engineer and shall be so designed that special tools are not required for such adjustment. Compensation for battery temperature shall be provided.

The charger shall have protection against overloads or short circuits and shall limit the output current. Recovery to a constant voltage characteristic shall occur automatically at the end of the overcurrent/short circuit.

(c) Boost Charging

Manual boost charging shall be provided. A boost timer shall be included to prevent overcharging.

Operation of boost charging shall disconnect the charger and battery from the load. It shall not be possible for both chargers to be selected to boost charging at the same time, or for the load to become disconnected from both batteries and chargers simultaneously.

If the a.c. mains supply fails during boost conditions the two batteries shall be automatically connected in parallel by “no volt” contactors to the load.

It shall not be possible to connect a “boosted” battery to the load until its terminal voltage has fallen below the load equipment upper voltage limit.

(d) Noise and Interference

To avoid unacceptable levels of electrical noise in the load equipment smoothing of the d.c. output is required. This shall achieve a psophometric noise level at the output, for loads between 0 and 100%, not exceeding the equivalent of 2 mV at a frequency of 800 Hz after weighting as specified by ITU-T (CCITT).

The relative harmonic content of the input current shall comply with the European Directive for EMC, the EN 60555-2 standard. In the case of SMPS chargers active power factor correction (i.e. boost for step up converter) shall be provided to control the power factor.

The production of radio frequency interference voltages shall not exceed the values of suppression grade “N”, as defined in EN 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.

(e) Efficiency/Rating

The charger efficiency shall not be less than 80%.

All chargers supplied shall preferably have the same rating, or be in fixed multiples, to limit the number of different charger ratings.

(f) Instruments, Controls and Alarms

The charger shall be equipped with the following

- a.c. mains input circuit breaker
- d.c. output circuit breaker
- charger output current meter
- charger output voltage meter
- alarms for charge fail, d.c. volts high etc.

Each alarm shall be provided with local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

13.9.4 Battery

(a) Type

Nickel cadmium cells shall be of the pocket plate type in accordance with IEC 623.

Cell containers shall be of the moulded plastic type, non flame propagating and mechanically shock resistant. They shall provide for the electrolyte level to be viewed through the container material.

Cells shall be permanently marked with the following information:

- manufacturer's reference number and code
- year and month of manufacture
- voltage and nominal capacity at the 10 hour rate
- cell number.

(b) Mounting

The batteries shall be mounted on metal stands, or racks, in a manner such that all the plates of each cell are visible for inspection, test and maintenance purposes. Stands or racks shall have a maximum of two tiers. In all cases adequate space must be left between the tiers for maintenance purposes and to permit the topping up of electrolyte. Stands or racks shall have a protective finish of not less than two coats of electrolyte resisting enamel or gloss paint. Alternatively, an epoxy resin sintered finish may be used.

At locations where the battery is not housed in a separate battery room the battery stand/rack shall be fitted with cladding. The cladding shall permit the free flow of air to the battery, and shall be removable for maintenance purposes.

Cell containers shall be accurately set up in alignment on the stand or rack with lead and/or rubber discs under the feet moulded on each container. Cell lids shall be so positioned that at least one topping up aperture is on the access gangway side of the cell and not obstructed by any inter-cell connecting arrangements.

(c) Battery Main Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated at five times the charger float output rated current. A cartridge fuse shall be provided in the charger input lead to the negative pole of the battery and rated at twice the charger float output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. These fuse links shall comply with BS 88.

Class DC 40 or equivalent and shall be mounted in fuse carriers with an insulated barrier between the poles.

The cable or busbar to the battery shall be firmly supported at a point near the cell terminal pillar. Where two cables are used they shall be terminated one to either side of the terminal pillar. These cables shall be arranged as to allow some flexibility and to avoid any forces being applied to the cell terminal pillar.

(d) Connections

The positive pole of each battery shall be connected to station earth via a single bolted link at the distribution cubicle. Low resistance intercell connectors shall be used. Connections between tiers of cells and between end cells and fuses shall be made with insulated copper rod which shall be of equivalent cross-section to the distribution busbars.

Connections from the battery fuses to the chargers and distribution cubicles shall be made with insulated cable of equivalent cross-section to the distribution busbars. The positive and negative terminals of each cell shall be clearly indicated. The positive and negative terminals of the complete battery shall be indicated by red and black marking respectively.

(e) Capacity

The battery capacities shall be 150 ampere hours at the 5 hour rate.

13.9.5 D.C. Distribution and Instrumentation

(a) General

The distribution section shall be designed for incoming and outgoing d.c. supplies as follows:

- two independent supplies (including one for future use) incoming from the batteries and associated chargers. The battery negatives shall be connected to the distributed busbar through a single pole switch. The 48V battery positive shall be directly connected to the positive busbar.

- Each load equipment shall be connected to a distribution outlet. The use of teed supplies to more than one load equipment will not be permitted.

- Double pole miniature or moulded case circuit breakers to IEC 157 shall be supplied, fitted with auxiliary contacts which operate when the circuit breaker trips.

The MCBs shall be rated to meet the load requirements and shall be labelled with the destination of the load. Outgoing connections shall be brought to terminals, mounted in the cubicle, provided with strip connectors and cable lugs. The number of outlets shall cater for the quantity of load equipment items plus 50%, with a minimum of 10 outlets being provided, Space shall also be available for the installation of 10 extra outlets for future use.

(b) Instruments and Alarms

Instrumentation shall comprise

- battery ammeter (charge and discharge)
- battery voltage
- load current ammeter
- busbar voltage

An alarm indication shall be provided if the busbar voltage falls outside set limits.

The MCB auxiliary contacts and the high/low voltage alarm shall each provide local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

13.9.6 Housing

The above covers the mounting/housing for batteries.

A modular construction is preferred for the battery charger and d.c. distribution/instrumentation, with each unit comprising a single 19" or ETSI standard rack configuration, all mounted in a single cubicle.

The modular construction shall provide:

- simple plug in units for easy assembly and servicing
- individual battery charger unit removal in safety, without loss of output power to the load.
- expansion of capacity at a later date

In the case of Contractors who do not offer a modular construction, separate cubicles are required for each charger and the d.c. distribution/instrumentation.

Appendix 13.A.1

SCHEDULE OF REQUIREMENTS FOR MULTIPLEXER

SL.No.	DESCRIPTION	UNIT	REQUIRED
1.0	GENERAL:		
1.1	Type of multiplexer		SDH: ADM
1.2	Complying to ITU-T rec.		Yes
1.3	Transmission Capacity	Mbit/s	STM-4: 620
1.4	Access capacity on 64 kbit/s	channels	Minimum 200
1.5	Access capacity on 2 Mbit/s	channels	Minimum 40
1.6	Redundant central processor		Shall be available
1.7	Digital cross connect function		Fully non-blocking
2.0	Available AGGREGATES:		
2.1	Optical aggregates (ITU-T G.957)		L-1.1, L-1.2
3.0	Available TRUNK INTERFACES:		
3.1	HDB3, 2 Mbit/s interfaces per module	No.	Minimum 8
3.2	Complying to ITU-T rec.		G.703, transparent G.704, selectable
3.3	HDSL, 2Mbit/s interface: no of copper wires Capacity on 2Mbit/s or on 1Mbit/s Capacity selectable	No. ch ch / pair of wire	4 or 2 30 or 15 30 / 2 pairs 30 / 1 pair 15 / 1 pair
4.0	Available USER INTERFACES		
4.1	Voice interfaces for trunk lines:		
4.1.1	1 + 1 com path protection, available for all		yes
4.1.2	Analogue, 4wire with E&M: Input level Output level	dBr	+7.5 .. –16 +7.0 .. –16.5
4.1.3	Analogue, 2wire with E&M: Input level Output level	dBr	+6.5 .. –12.5 –1.0 .. -20
4.1.4	Digital, 2Mbit/s CAS or PRI		yes
4.2	Voice interfaces for remote subscriber:		
4.2.1	2wire, subscriber side	dBr	-5 .. +4 / -7.5 .. -1
4.2.2	2wire, PABX side	dBr	-5 .. +4 / -7.5 .. -3
4.3	Integrated teleprotection		

4.3.1	Interface for Commands:		
4.3.1.1	Number of independent commands	No.	4
4.3.1.2	Transmission time max.	ms	6
4.3.1.3	Signal voltage	Vpeak	250
4.3.1.4	1 + 1 com path protection		yes
4.3.2	Interface(s) for Differential Protection:		
4.3.2.1	Electrical interface: G.703	kbit/s	64
4.3.2.2	Optical Interface	kbit/s	Minimum 64
4.4	Data: channels per module		
4.4.1	1 + 1 com path protection, available for all		yes
4.4.2	V.24/V.28 (RS-232): up to 38.4kbit/s	No.	4
4.4.3	V.11/X.24 (RS-422): 64kbit/s	No.	4
4.4.4	V.35: 64kbit/s	No.	4
4.4.5	V.36 (RS-449): 64kbit/s	No.	2
4.4.6	G.703: 64kbit/s	No.	8
4.4.7	Ethernet: 10/100 BaseT WAN capacity Protocols	No. Mbit/s	1 Min: 2x 2Mbit/s Min.: IP
4.5	Integrated alarm gathering module:		
4.5.1	Number of external alarms per module	No.	Min. 20
4.5.2	Auxiliary power supply for ext. contacts		Yes
4.6	Network Management System		
4.6.1	Type/Name of configuration tool		
4.6.2	For fault / configuration management		Yes / yes
4.6.3	For local / remote operation		Yes / yes
4.6.4	Data communication network (DCN)		Ethernet / IP or Ethernet / OSI
4.7	Ambient Conditions:		
4.7.1	Storage: ETS 300 019-1-1, class 1.2	°C / % hum	-25 .. + 55 / class 1.2
4.7.2	Transport: ETS 300 019-1-2, class 2.2	°C / % hum	-25 .. + 70 / class 2.2
4.7.3	Operation: ETS 300 019-1-3, class 3.1E	°C / % hum	-5 .. +45 / class 3.1E
4.8	Power Supply		
4.8.1	Operation	VDC	48 / 60 (-15/+20%)
4.8.2	Fully redundant power supply		yes

SECTION 14

POWER CABLES AND CABLE TERMINATING ACCESSORIES

TABLE OF CLAUSES

SECTION 14

POWER CABLES AND CABLE TERMINATING ACCESSORIES

14.1 SCOPE

These clauses describe the General Technical Requirements for the 230kV, 132 kV & 33 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 power cables and accessories shall be suitable for connecting the overhead transmission lines, power transformers with GIS.

The 33 kV cables and accessories shall be suitable for connecting the tertiary side of 230/138/33kV, 250/350 MVA three phase power transformers with 33/0.4 kV earthing/auxiliary transformers.

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

The design shall be proven by the submission of test certificates 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.

14.2 STANDARDS

The cable and accessories shall comply with this specification and the latest version of relevant IEC, BS or approved equivalent.

14.3 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, 132 kV & 33 kV and the highest operating voltage Um will be 245kV, 145 kV & 36 kV.

The maximum foreseeable three phase symmetrical fault current to which the cables may be subjected is 280kA at 230KV, 140kA at 132KV and 25kA at 33 kV for one second.

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 230kV,132 kV and 33 kV cable shall be 50kA, 40kA(for 1600mm^2), 25kA(for 1000mm^2), and 5kA 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: 500 MVA
- Transmission capacity for 132 kV cable circuit: 300 MVA
- Transmission capacity for 33 kV cable circuit: 120 MVA

Other conditions for cables laid in concrete ducts/tunnels/buried pipes shall be assumed:-

- Max. ambient air temperature: 40°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.

14.4 TYPE APPROVAL

Cables and accessories shall have satisfactorily passed type approval tests in accordance with the Specification and details of the cable designs offered shall be given in the 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 satisfactorily 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.

14.5 CABLE LENGTHS

Cables shall be supplied in maximum drum lengths bearing in mind the transport limitations in gaining access to the site. No drum shall contain more than one length. 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.

14.6 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 handed over to the Purchaser's stores. Particulars of the cable (as stated above) shall be clearly marked on one flange.

14.7 SPARE CABLE

In addition to the cable maintenance lengths supplied against the Schedule of Spares the Purchaser 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.

14.8 SPECIAL TOOLS

Special tools used for the purpose of the cable installation, they shall be handed over to the purchaser's stores after the taking over of the installation.

Price for such special tolls is to be considered as included in the price schedule.

14.9 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 Purchaser.

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.

14.10 CABLE SPECIFICATION

14.10.1 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.

14.10.2 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.

14.10.3 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.

14.10.4 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.

14.10.5 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 interface smooth.

14.10.6 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 metallic layer shall be Copper screen with counter helix filled with swelling powder sheathed in accordance with latest BS or IEC Publication.

14.10.7 Intermediate Layer

An intermediate layer of suitable compound shall be provided in between metallic screen and aluminium sheath if necessary.

14.10.8 Corrugated Seamless Aluminium Sheath

Metallic sheath shall consist of the extruded corrugated seamless aluminum sheath. Aluminum 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.

14.10.9 MDPE Outer Sheath

After applying the bitumin 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.

14.10.10 Identification of Cable

The outer PVC sheath of all cables shall carry the following identification marks in three meter intervals approximately.

"ELECTRIC CABLES - 132000 Volts/33000 Volts and cross section in sq. mm.cu. PGCB, the name of the manufacture and the year of fabrication."

The letters and numerals shall comply with IEC or BS Publication.

14.11 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.

14.12 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 moisture. 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.

14.13 INSTALLATION OF CABLE

14.13.1 Cable Tunnels and Trenches with Pits, Ducts and Drains

The contractor shall design and construct cable tunnels /Trenches required for connecting/Laying 230 kV,132 kV& 33kV 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.

At least one additional cable shall be laid to future use for every six(6) cable of each two 230kV circuit and the terminal shall be sealed properly. The employer will finalize the number of spare cable with length to be installed during detail engineering.

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 withstand a load of 2,500 N at the center of each cover. The trench covers shall be of such size as to facilitate their handling by manual labor.

14.13.2 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.

14.13.3 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.

14.14 TESTS

14.14.1 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 laboratories.

If the cable is not yet type tested, the relevant tests shall be carried out.

14.14.2 Routine/Sample Tests

The cable shall be tested and shall satisfy the most recent relevant IEC Publication.

14.14.3 Tests at site

After completion of the erection and before commissioning, each cable shall be submitted to the following test:

a) Verification of the proper and complete erection of the cable and the terminals.
b) Verification of the proper conductor's of the external surface.
c) Verification of the proper earthing of the sheath.
d) Direct current voltage test no cables and cable terminals.
e) Power frequency test.

14.15 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.

SECTION 15

QUALITY ASSURANCE, INSPECTION, TESTING, COMMISSIONING AND WARRANTY

TABLE OF CLAUSES

SECTION 13

QUALITY ASSURANCE, INSPECTION, TESTING, COMMISSIONING AND WARRANTY

13.1 SCOPE OF SECTION

The whole of the plant covered by this Contract shall be tested as detailed in this specification and as per standard engineering practice, at contractor's cost, and will be subject to inspection and witnessing the tests by the Employer during manufacture, erection and on completion. The inspection and witnessing the tests at manufacturer's works may be done by the Employer or an Independent Inspection agency. The approval of the Employer/Engineer or the passing of any such inspection or test will not, however, prejudice the right of the Employer to reject the plant if it does not comply with the specification when erected or when in service.

Within 40 days of the Letter of Acceptance for the Contract the Contractor shall submit a quality assurance programme and a work quality programme for the Engineer's approval. It shall be submitted on the Engineer's standard form, a sample of which is included at the end of this Section.

The Contractor shall have an approved Quality Management System, which shall cover all activities being undertaken during the design, procurement, manufacturing, inspection, testing, packaging, shipping, storage, installation and erection and commissioning of the Works.

After the award of Contract, the Engineer shall have the right to carry out a review of the quality assurance procedures operated by the Contractor. The Engineer's review may consider quality assurance in relation to the design and manufacture of plant items, but may equally investigate the Contractor's quality assurance procedures for the overall control of the wide range of design activities necessary for a complex project of this type, and the dissemination of paperwork, design drawings and data amongst the various design and manufacturing organizations within the Contract. The Contractor shall give all necessary help and assistance to the Engineer in carrying out such a quality assurance review. 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 dispatched 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 Sub-Contractors to enable the Engineer and Employer to carry out the necessary inspection and witnessing of tests.

In the cases where tests or inspection are specified as being carried out on only a sample of the total quantity of items in the Works, and where one or more items of the sample fail the test or inspection, a further batch of the items, at least equal in quantity to the proportion originally specified, shall be tested or inspected. This process shall continue until a sample proves completely acceptable.

15.2 SUB-CONTRACTS

Within two months of acceptance of the Bid and in order to facilitate the inspection of bought-out materials 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 dispatched to Site direct from the Sub-Contractor's factory.

Sub-orders are to include a statement advising the Sub-Contractor that the items being ordered will be subject to inspection and test by the Engineer and Employer.

The Contractor shall advise his Sub-Contractors of all the pertinent clauses in the Specification when ordering bought out plant, equipment or materials.

Every sub-order or sub-contract shall contain the following information:

(a) Main Contractor's name and sub-order or sub-contract number.
(b) Quantities and description of work.
(c) Delivery requirements.
(d) Delivery consignment instructions.
(e) Details of Employer and/or main Contractor's applicable drawing or schedule numbers.
(f) Name of the Engineer.
(g) A note advising that the plant or equipment which is the subject of the order shall comply in every respect with the Engineer's, Specification and shall be subject to inspection by the Engineer, Employer and the Contractor.
(h) A reference, particularized in the accompanying Specification, covering the following information:
Employer’s name
Project title
Contract No.
Engineer's reference number
Sub-Contractors shall comply with all the applicable requirements of this Specification and the onus are upon the Contractor to ensure that Sub-Contractors comply with these requirements.

For the purposes of this clause, interworks orders shall be treated as sub-orders.

15.3 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 Documents.

The tolerances permitted in the IEC and BS shall apply unless otherwise stated.

15.4 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 organization.

15.5 MEASURING AND TESTING EQUIPMENT

At prescribed intervals, or prior to each use, all measuring and testing equipment used in inspection shall be calibrated and adjusted against certified equipment having a known valid relationship to internationally recognized standards.

The manufacturer shall prepare a calibration schedule showing equipment type, identification number, location, frequency of checks, method of checking and action to take when results are unsatisfactory.

15.6 INSPECTION PLAN AND PROCEDURE

The Inspection Plan, as submitted by the Contractor to the Engineer for approval, shall cover the following:

(a) Relevant International Standard. For each of the following stages of the work, the acceptance criteria shall be stated.

(b) The stages of inspection which shall include but not be limited to the following:

i) Tests to review or approve certification of material;
ii) Review and approval of manufacturing procedures;
iii) Witnessing tests or review and approval of certification of operator's qualification to carry out the work required;

iv) Visual and dimensional examination of components;
v) Pressure tests on casings and vessels;
vi) Non-destructive examination of materials in progress;
vii) Functional tests on sub-assemblies, performance tests, type tests on complete units;
viii) Examination of painting, packing and documentation for shipment.

The Engineer will indicate the inspection requirements on the agreed inspection programme in accordance with the following.

Hold point - Requires a mandatory inspection by the Engineer. This inspection or test shall be witnessed by the Engineer and Employer and further progress in manufacture shall not be made until the plant is approved by the Engineer.

Witness point - Inspection or test of material may be carried out by the Engineer and Employer at their discretion.

Document review - Certification of material and functional test shall be approved by the Engineer before despatch from the works.

13.7 TEST CERTIFICATES

Triplicate sets of all test records, test certificates and performance curves, whether or not they have been witnessed by the Engineer and Employer, shall be supplied to the Engineer for all tests carried out in accordance with the provisions of this Contract.

Sets of all test certificates shall be endorsed with sufficient information to identify the material or equipment to which the certificates refer, and shall carry in the top right hand corner the following reference:

Employer's name
Project title
Contract No.
Engineer's reference number

All test documentation shall be in the English language.

13.8 MATERIAL TESTS

The Contractor shall provide test pieces as required by the Engineer to enable him to confirm the quality of the material supplied under the Contract. Such test pieces shall be prepared and supplied free of charge and any cost of the tests shall be borne by the 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 Contractor's or Sub-Contractor's designers and metallurgists will be consulted before any material is so rejected.

If the Engineer is furnished with certified particulars of tests which have been carried out for the Contractor by the suppliers of material, he may, at his own discretion, dispense with the previously mentioned tests.

13.9 GENERAL REQUIREMENTS FOR TESTS AT MANUFACTURERS' WORKS

15.9.1 Testing of Plant

Tests at manufacturers' works shall include mechanical, electrical and hydraulic tests to ensure that the plant being supplied complies with the requirements of the Specification.

Works tests shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant IEC or BS, except where departures therefrom and modifications thereto are embodied in this Specification.

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 Sub-Contractors' 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.

13.9.2 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.

15.10 SPECIFIC REQUIREMENTS FOR TESTS AT MANUFACTURERS' FACTORIES

15.10.1 Pressure Vessels

(a) All pressure vessels shall be designed, fabricated, inspected and tested in accordance with an approved pressure vessel code or standard.

(b) An approved method of radiographic or other 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 programme of non-destructive testing before heat treatment.

(c) Hydrostatic test shall be conducted in accordance with BS 5500.

15.10.2 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.

(a) Accuracy of calibrated pick-up and drop-off levels over the effective range of settings
(b) Insulation tests
(c) Accuracy of timing elements
(d) Correct operation of flag (or other) indicators
(e) Mechanical requirements, integrity/safety of draw-out units, check of contact pressure and alignment.

15.10.3 Electrical Instruments and Meters

One instrument and meter of each type and rating shall be subjected to the tests as specified in IEC 60051.

15.10.4 AC Switchboards

Routine tests shall include general inspection and electrical operation tests.

15.10.5 Contactors

One contactor of each type and rating shall be subjected to type tests as specified in IEC 292-1.

15.10.6 PVC Cable

Each size and rating of PVC cable shall be subjected to type tests as specified in BS 6346.

15.10.7 Current and Voltage Transformers

Routine tests to IEC 60044-1 and IEC 60044-2.

13.10.8 Surge Arresters

The following routine tests shall be carried out on all arrester units in accordance with clause 9.1 of IEC 60099-4.

(a) measurement of reference voltage
(b) residual voltage test
(c) internal partial discharge test
(d) housing leakage test

The following acceptance tests shall be carried out on one complete arrester of each voltage rating and/or type being supplied, all in accordance with Clause 9.2 of IEC 60099-4.

(a) measurement of power frequency voltage at the reference current

(b) lightning impulse residual voltage at nominal discharge current
(c) internal partial discharge test

15.10.9 Batteries and Battery Chargers

Battery - The Contractor shall demonstrate that the battery will perform the duties specified.
Battery Charger - Routine tests according to IEC 60335.
DC Switchboard - Routine tests according to IEC 60439.

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.

15.10.10 Control Panels

Routine operation tests and insulation resistance tests shall be carried out.

15.10.11 Instruments

Calibration tests shall be witnessed on all important pressure gauges and other instruments as required by the Engineer.

15.10.12 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 or British Standard, except where departures therefrom and modifications thereto are embodied in this Specification. For Plant not covered by any IEC or British 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 dispatched to Site until the Employer has given his approval in writing.

15.10.12.1 Main Transformers

Routine Tests

All transformers shall be subject to the following routine tests in accordance with IEC 60076 and the requirements of this Specification.

i) Measurement of winding resistance on all tap positions and phases
ii) Measurement of voltage ratio and check of phase displacement
iii) Measurement of short-circuit impedance and load loss
iv) Measurement of no load loss and current
v) Tests on on-load tap-changers
vi) Dielectric Routine Tests:
The test shall be carried out in accordance with IEC 60073-3.

Type Tests

i) Temperature rise test:
The test shall be in accordance with IEC 60076-2, and shall be carried out on one transformer of each size and type. Temperature-rise tests shall be conducted on the tapping corresponding to the maximum losses.

ii) Noise level tests:
A noise level test to IEC 60076-10 shall be carried out on one transformer of each type.

Special Tests

i) Measurement of zero-sequence impedance in three phase transformers:
The test shall be in accordance with IEC 60076-1 Clause 10.7 and shall be carried out on one transformer of each type.

15.10.12.2 Voltage Control Equipment

Routine Tests

Each finished tap changer shall be subjected to the routine tests specified in IEC 60214 but in addition the mechanical test shall be carried out at rated voltage and no load.

Type Tests

Shall be carried out entirely in accordance with IEC 60214 except that evidence of the service duty type test shall be in excess of 100,000 operations.

15.10.12.3 Magnetic Circuit

Routine Tests

Each core completely assembled shall be tested for one minute at 2,000V AC between core bolts, side plates, structural steelwork and core at the core and coil stage. After the transformer is tanked and completely assembled, a further test shall be applied between the core and the earthed structural steelwork to prove that the core is earthed through the removable link, at one point only.

15.10.12.4 Outdoor Bushing Assemblies with Porcelain Insulators

Complete bushings tested in accordance with IEC 60137

Routine Tests

To include:

i) Oil leakage test
ii) 50Hz dry withstand test
iii) Power factor/voltage test
iv) Partial discharge test on all bushings of which the major insulation is either oil impregnated paper or resin impregnated paper.

15.10.12.5 Tanks

Routine Tests

Oil Leakage:

All tanks, conservators and oil filled compartments, which are subjected in service or during maintenance to oil pressure, shall withstand without leakage a hydraulic pressure test equal to 69 kN/m^2 or the normal pressure plus 34 kN/m^2, whichever is the greater, for 24 hours during which time no leakage or oil ingress into normally oil free spaces shall occur.

15.10.12.6 Cooling Plant

Routine Tests

(a) Coolers: Pressure test to be as specified above.
(b) Motors and Control Gear: To the requirements as specified.

15.10.12.7 Gas and Oil - Actuated Relays

Routine Tests

(a) Oil Leakage:
When subject to an internal oil pressure of 207 kN/m^2 for fifteen minutes.
(b) Gas Collection
(c) Oil Surge
(d) Performance test under service conditions
(e) Voltage: 2 kV for one minute between electrical circuits and casing.

15.10.12.8 Galvanizing

Routine Tests

To the requirements of BS 443 or BS 729 whichever is applicable.

15.10.13 GIS Equipment.

Clause reference of type tests and routine tests are listed below. Any other tests specified by the referred standard (current and future issues) but not listed shall be applicable as well.

Type tests shall have been carried out on the switchgear components in accordance with the relevant IEC and BS Standards. Limiting values obtained during Type Test shall form basis for Factory Acceptance Tests. The limiting values shall be highlighted in the Routine Test Reports/Witness Tests.

Routine Tests

(a) One Complete Bay

<u>IEC 62271-203 clause</u> (for 132kV and 230kV GIS)

7.1 .1	Power-frequency voltage tests on the main circuit
7.1.2	Partial discharge measurement
7.2	Tests on auxiliary and control circuits
7.3	Measurement of the resistance of the main circuit
7.4	Tightness test
7.101	Pressure tests of enclosures
7.102	Mechanical operation tests
7.103	Tests of auxiliary circuits, equipment and interlocks in the control mechanism
7.104	Pressure test on partitions

<u>IEC 62271-200 clause</u> (for 33kV GIS)

7.1	Dielectric test on the main circuit
7.2	Tests on auxiliary and control circuits
7.3	Measurement of the resistance of the main circuit
7.4	Tightness test
7.102	Mechanical operation tests
7.103	Pressure tests of gas-filled compartments
7.104	Test of auxiliary electrical, pneumatic and hydraulic devices

(b) Circuit Breaker

<u>IEC 62271-100 Clause</u>

7.1	Dielectric tests on the main circuit
7.2	Tests on auxiliary and control circuits
7.3	Measurement of the resistance of the main circuit
7.4	Tightness test
7.5	Design and visual checks
7.101	Mechanical operation tests (including resistance and current

measurements of closing and trip coils and checking anti-pumping function)

(c) Disconnector & Earth Switch

IEC 62271-102 Clause

7.1 Dielectric tests on the main circuit
7.2 Dielectric tests on auxiliary and control circuits
7.3 Measurement of the resistance of the main circuit
7.101 Mechanical operation tests (including verification of early make/late break feature of disconnector auxiliary contacts as applicable)

(d) Current Transformers IEC 60044-1, BS 3939

Routine Tests to all current transformers will be done as per specified standards. Additional Tests required by PGCB.

Measurement of Secondary winding resistance
Measurement of magnetizing current characteristics of all CTs
Determination of Turns ratio Error for class X CTs
Verification of knee-point voltage for Class X CTs

(e) Voltage Transformers IEC 60044-2

Routine Tests applicable to voltage Transformers as per specified standards.

(f) Surge Arresters

Routine Tests as per specified in Clause 13.10.8 in this Section.

(g) Insulators

Routine tests to
IEC 60137 for bushings
IEC 60168 and 60273 for high voltage post insulators
IEC 60383 and 60305 for cap and pin string insulators

The performance of the components of the switchgear shall be substantiated by test data relevant to the particular designs offered.

Evidence of type tests shall be submitted with-the Bid.

Evidence of Type Tests should be provided, including the hydraulic system, for ambient temperature of 45°C and 100% humidity.

No additional costs will be allowed for type testing to meet specified requirements and should deficiencies in existing type test evidence occur then the cost of such additional or repeat tests as may be required by PGCB shall be deemed to be included in the Contract Price.

The Bidder will be deemed to have included in his price the operation test at high temperatures in accordance with IEC 62271-203.

(h) Local Control Cubicle

Major components of LCCs are to be tested and calibrated. Functional testof LCC s are to be carried out in the factory during factory acceptance test.

Type Tests

(a) One Complete Bay

<u>IEC 62271-203 Clause</u> (for 132kV and 230kV GIS)

6.2	Dielectric tests
6.4	Measurement of the resistance of circuits
6.5	Temperature-rise tests
6.6	Short-time and peak withstand current tests
6.7	Verification of the protection
6.8	Gas tightness tests
6.104	Pressure test on partitions
6.105	Test under conditions of arcing due to an internal fault
6.106	Insulator tests

<u>IEC 62271-200 Clause</u> (for 33kV GIS)

6.2	Dielectric tests
6.4	Measurement of the resistance of circuits
6.5	Temperature-rise tests
6.6	Short-time and peak withstand current tests
6.7	Verification of the protection
6.8	Tightness tests
6.103	Pressure withstand test for gas-filled compartments

(b) Circuit Breaker

<u>IEC 62271-100 Clause</u>

6.2	Dielectric tests
6.4	Measurement of the resistance of circuits
6.5	Temperature-rise tests
6.6	Short-time and peak withstand current tests
6.101	Mechanical and environment al tests
6.102	Miscellaneous provisions for making and breaking tests
6.103	Test circuits for short circuit making and breaking tests
6.104	Short-circuit test quantities
6.105	Short-circuit test procedure
6.106	Basic short–circuit test-duties
6.108	Single-phase and double-earth fault tests
6.109	Short-line fault tests
6.110	Out-of-phase making and breaking tests

6.111 Capacitive current switching tests

(c) Disconnector & Earth Switch

IEC 62271-102 Clause

6.2 Dielectric tests
6.4 Measurement of the resistance of circuits
6.5 Temperature-rise tests
6.6 Short-time and peak withstand current tests
6.101 Tests to prove the short-circuit making performance of earthing switches
6.102 Operating and mechanical endurance tests
6.104 Operation at the temperature limits
6.106 Bus-transfer current switching tests
6.107 Induced current switching tests

(d) Current Transformers IEC 60044-1, BS 3939

Type tests for Measuring Current Transformers & Protective Current transformers shall be done as per specified standards.

(e) Voltage Transformers IEC 60044-2

Type Tests for all Voltage transformers shall be done as per specified standards.

(f) Surge Arresters IEC 60099-4

Type Tests shall be done as per specified standards.

15.10.14 Fibre Optic Multiplexer Equipment

Works tests shall be in accordance with the IEC stansdard.

15.10.15 Transducers

Transducers shall be tested in accordance with IEC 60688.

15.11 DISMANTLING PRIOR TO SHIPMENT

After the satisfactory completion of all tests at the factory, the plant shall be submitted for the Engineer's approval during dismantling preparatory to shipping. No item of plant shall be dispatched to site until the Engineer has given approval in writing.

15.12 INSPECTION AND TESTING DURING SITE ERECTION

15.12.1 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 reference to the equipment and items to which they refer, so that the record can be used as the basis for maintenance tests during the working life of the equipment. The required number of site test result records shall be provided by the 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 bearing on the test results.

The testing requirements detailed under this Specification may be subject to some variation upon the instruction or agreement of the Engineer where necessitated by changed conditions at Site or by differing design, manufacture, or construction techniques.

The Bider is required to submit proposals for site dielectric tests and to include in his price the costs of such tests and of such equipment as deemed necessary.

15.12.2 Mechanical Equipment

The extent of testing during erection shall include, but not be limited to, the following:

(a) Checking the accuracy and alignment of plant erected. The accuracy shall comply with the relevant standards, the specification or the plant manufacturer's requirements as may be applicable or, where no requirements exist, to a standard to be agreed between the Engineer and the Contractor.

(b) Checking the alignment of rotating equipment to the manufacturer's requirements.

(c) Non-destructive testing of site welds as required by the relevant standard and as detailed in this specification.

(d) Hydrostatic testing of pipework systems at a pressure of 1.5 times the design pressure but not less that 4.5 bar for a period of 2 hours, or at such other conditions as may be required by the pipework design code.

Air piping shall be subjected to an air pressure test rather than a hydrostatic test.

(e) Site fabricated tanks and vessels shall be subjected to hydrostatic tests in accordance with the relevant standards.

(f) Hydrostatic tests shall be carried out on steam generating units in accordance with the boiler design code.

After the hydrostatic test is carried out, the complete assembly shall be drained and any non-drainable sections shall be injected with an oxygen-absorbent chemical and elements plugged.

(g) Pressure vessels and other parts, including pipework, that are made up on site and are subject to pressure or vacuum under normal or abnormal working conditions, shall be subjected to a site hydraulic test at approved pressures and for approved periods in accordance with the relevant standard. Where no appropriate standard exists the hydraulic test pressure shall not be less than 1.5 times design pressure or at such pressure to be agreed by the Engineer.

Should, in the opinion of the 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.

(h) Calibration checks on all instrumentation.

(i) Tests to demonstrate the correct functioning of the control loops, protective devices, interlocks and alarms.

(j) Flushing out of all pipework systems which have not been fully cleaned and sealed before shipping to site.

(k) Other tests as specified which have not been previously conducted.

15.12.3 Electrical Equipment

15.12.3.1 General

A general check of all the main switchgear and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, labelling, arcing ring and horn gaps, clearances, painted surfaces, cables, wiring, pipework, valves, blanking plates and all other auxiliary and ancillary items. Checks shall be made for oil and gas leaks and that insulators are clean and free from external damage. A check shall be made that loose items which are to be handed over to the Employer e.g. blanking plates, tools, spares, are in order and are correctly stored or handed over.

The following general tests are to be carried out on electrical equipment after erection at site:-

(a) Routine high voltage tests to the appropriate IEC Standard. Where no relevant standard exists, tests shall be agreed with the Engineer.
(b) Insulation resistance tests on all electrical equipment.
(c) Continuity and conductivity resistance tests.
(d) Test operation of alarm and tripping, devices to local and remote.
(e) Rotational tests on all motors.
(f) Polarity tests on CTs and VTs.
(g) Oil tests.
(h) Grounding system and electrode tests.
(i) Ratio, Vector Grouping and magnetising current tests on each transformer.
(j) Calibration of winding and oil temperature devices.
(k) Vector group and phasing tests on VT circuits.
(l) Magnetisation current/voltage tests and winding resistance tests on all current transformers.
(m) Primary and secondary injection tests on relays, protection devices and equipment.

15.12.3.2 GIS Equipment

(a) General check up as per manufactures drawings and instructions

- Visual checking
- Tightness checks of nuts and bolts
- All piping and junction checks
- Tightening of all terminal block connection.
- Painting and corrosion protection.
- Cleanliness.

(b) General wiring checking

(c) Insulation checking of the auxiliary circuit and the control circuit

(d) Heating and lighting circuit checking

(e) SF6 gas purity check

(f) SF6 gas dew point check

(g) SF6 gas leakage test check

SF6 gas leakage is to be checked by leak detector and gas pressure are to be monitored for at least 7 detector and gas pressure are to be monitored for at least 7 days.

(h) SF6 gas density monitors calibration checking

(i) SF6 gas density monitors contact setting checking

(j) Hydraulic drive unit operational check:-

- Pump motor operation check.
- Hydraulic drive unit gauge check.
- Oil pressure loss check.
- Pump motor running time check.
- Accumulator pre-pressure check.
- Accumulator loss of pressure alarm and lock out check.

(k) On an increasing pressure measurements on:-

- Reset of the opening lockout.
- Reset of the closing lockout.
- Disappearance of the low pressure alarm.
- Cut-off of the pumping device.
- Opening of the safety valve. contd.

(l) On a dropping pressure measurement on:-

- Closing of the safety valve.
- Starting of the pumping device.
- Appearance of the low pressure alarm..
- Closing lockout.
- Opening lockout -1

- Opening lockout -2.

(m) Circuit breaker test:-

- CB opening and closing time.
- Closing at lock out pressure
- Opening at a lock out pressure.
- Anti pumping device operational check.
- Closing coil resistance and tripping coil resistance.
- Measurement of current of closing coil and trip coils.

(n) Motor operation and timing tests on disconnector and earth switch

Verification of early make/late break feature of disconnector auxiliary contacts as applicable

(o) Spring motor charging time

(p) Measurement of the resistance of the main circuit

(q) Operational test (local, remote, supervisory)

(r) Alarm annunciation (local, remote, supervisory)

(s) Synchronization checking

(t) Surge arrester test

It is to be tested at rated voltage and leakage current is to be recorded (surge arrester leakage current guaranteed value is to be supplied from the manufacturer).

(u) Interlock check

(v) Annunciation check

(w) Record pressure gauge and counter readings before commissioning

(x) CT/VT/Relays & Meters

Any additional tests recommended by the manufacturer shall be added to the above list. Equipment not covered by the above site test list shall be tested based on standard practice.

15.12.3.3 Earthing System

Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid corrosion attack on the earthing system.

The earth resistance shall be measured during the installation and on completion as follows:

(a) of each earth rod after driving
(b) of the earth grid after completion and backfilling of the trenches
(c) of each group of earth rods or earth point after completion of the connection from the test link terminal
(d) of the completed installation without any connections outside the substation

The tests shall be carried out by a method and with equipment approved by the Engineer. All tests are to be witnessed and the equipment and method used recorded with the test results.

The Contractor may also be called upon to provide assistance in the measurement of earth resistance after earth connections to the system have been completed.

15.12.3.4 Control Relays and Metering Panels, Instruments and Protective Devices

(a) Wiring

After complete erection and cabling, all circuits shall be subjected to the high voltage test specified in the relevant IEC or approved standard.

The insulation resistance of all circuits shall be measured before and after any high voltage tests.

For AC secondary injection tests a substantially sinusoidal test supply shall be used.

The operating and resetting level (current and/or voltage) and timing of all relays shall be measured over an agreed range of settings for all relays.

For directional relays 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 energized by switching on or inserting fuses or links.

(b) Mechanical Inspection

All panel equipment is to be examined to ensure that it is in proper working condition and correctly adjusted, correctly labelled and that cases, covers, glass and gaskets are in good order and properly fitting.

(c) General

Sufficient tests shall be performed on the relays and protection schemes to:

i) establish that the equipment has not suffered damage during transit.
ii) establish that the correct equipment has been supplied and installed.
iii) confirm that the various items of equipment have been correctly interconnected.
iv) confirm performance of schemes designed on the bases of calculation e.g. differential protection.
v) to provide a set of figures for comparison with future maintenance values allowing the condition of the equipment to be determined.

(d) Secondary Injection

Secondary injection shall be carried out on all AC relays, using voltage and current of sinusoidal wave form and rated power frequency to confirm satisfactory operation and range adjustment.

The polar characteristic of all distance protections shall be recorded at a minimum of 30 degree intervals.

For circulating current protection employing high impedance voltage operated relays, the points of injection for relay voltage setting tests shall be across the relay and stabilizing resistance.

The fault setting for the type of protection is to be established by secondary injection, where it is impracticable to ascertain this value by primary injection. Injection is to be made across the appropriate relay bus wires with all associated relays, setting resistors, and CT's connected.

(e) Primary Injection

All current operated relays shall be tested by injection of primary current to record the actual relay setting and as a final proof of the integrity of all secondary connections.

The stability of all differential schemes shall be checked by injection of primary current.

Primary current injection tests are to be carried out by the Contractor and the methods employed for a particular installation are to be agreed with the Engineer.

Tests are to be carried out as follows:-

i) Local primary injection to establish the ratio and polarity of current transformers as a group, care being taken to prove the identity of current transformers of similar ratio.
ii) Overall primary injection to prove correct interconnection between current transformer groups and associated relays.
iii) Fault setting tests, where possible, to establish the value of current necessary to produce operation of the relays.

(f) DC Operations

Tests are to be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indications and alarms. The correct functioning of all isolation links and fuses shall also be checked.

(g) Tests on Load

Tests on load shall also be done to demonstrate stability and operation of protection relays as required by the Engineer.

All tripping, control, alarm and interlocking circuits shall be functionally tested to prove satisfactory and foolproof operation and/or resetting. The functional and safety aspects of all shorting and/or isolation links, fuses and switches devices shall be proved.

The total burdens connected to all voltage transformer circuits shall be measured and recorded.

The total capacitance of all wiring and apparatus connected to the negative pole of each main tripping battery shall be measured and recorded; the value shall not exceed 10 microfarad.

The continuous current drain of all trip circuit supervision relays shall be measured and shall not be greater than half the minimum current required for tripping. The supervision current shall be measured with the circuit-breaker (or other device) both open and closed.

15.12.3.5 Batteries and Chargers

Tests shall be carried out on the batteries and chargers to confirm the charger ratings and adjustment, the battery and charger alarm systems and battery capacity.

The open-circuit cell voltages of the batteries when fully charged shall be recorded.

The insulation to earth of the complete DC installation shall be tested.

15.12.3.6 Power Cables

Each completed circuit shall be tested for continuity and insulation resistance.

15.12.3.7 Control and Instrumentation Equipment

The following general tests shall be performed on control and instrumentation equipment at site:

(a) High voltage testing of all circuits, as specified in the relevant IEC or approved standard.
(b) Insulation resistance testing of all circuits.

(c) Functional tests of all tripping, control, alarm and interlocking circuits.
(d) The testing of all equipment in accordance with the manufacturer's instructions or as advised by the Engineer.

15.12.3.8 Transformers and Ancillary Equipment

The following tests shall be performed.

i) Insulation resistance tests on bushings.
ii) Insulation resistance test at 500V between core and core clamping structure.
iii) Voltage withstand tests on insulating oil to BS 148.
iv) Ratio.
v) Phase relationship.
vi) Magnetisation characteristics of current transformers of winding temperature devices.

vii) Calibration of winding temperature devices.
viii) Tap Selector and Diverter Switch alignment.
ix) Calibration of automatic voltage control equipment.
x) Proving tests as necessary on control schemes.
xi) Measurement of winding resistance on all taps and phases.

Where applicable the above tests shall also be carried out on Auxiliary Transformers.

15.12.3.9 Fibre Optic Multiplexer Equipment, Teleprotection and Communication

Tests shall be exhaustive and shall demonstrate that the overall performance satisfies every requirement specified.

The tests to be carried out shall be:-

(a) Physical inspection unit testing and demonstration of diagnostic aids as appropriate of al equipment in stand alone mode.
(b) System testing of 48V power supply equipment.
(c) System testing of fibre optic multiplexer equipment for speech and teleprotection, including unit tests on coupling equipment and line frequency characteristics (between co-axial cable ends).
(d) System testing of telephone equipment.
(e) System testing of teleprotection equipment to plant.

15.13 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 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 operating 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 organization 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 Sub-Contractor's or seconded staff, observe all prescribed safety rules and permit systems.

15.14 TAKING OVER

After satisfactory completion of the tests on completion, the Engineer will issue a Taking Over Certificate for the plant. The issue of any such certificate shall not however relieve the Contractor of any of his responsibilities in respect of proving that the performance of the plant meets the guaranteed values.

The Taking Over Certificate shall make reference to a schedule of outstanding minor defects and omissions which have been accepted by the Engineer as not affecting the full and safe operation of the plant. The 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.

15.15 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 guarantee period for such a part shall be extended, commencing from the date at which the remedial work was completed.

Immediately prior to the completion of this period the Employer reserves the right to request the Contractor to open up for inspection the whole or any part of the Plant. The Employer will provide the labour to work under the direct supervision of the Contractor's representative for the purpose of such inspection.

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.

15.16 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 Certificate will be issued after all the said obligation has ceased. Final Certificate will be issued after all the said obligation has ceased. Where the 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.

SECTION 15 - APPENDIX A

REF. NO.	ITEM OR COMPONENT	PROCESS	DESCRIPTION OF OPERATION	DOCUMENTATION	SPECIFICATIONS/STANDARDS	PROG DATE	ACTION BY		
							CONTRACTOR	EPL	THIRD PARTY

<table>
<tr><td rowspan="5">Quality Assurance & Inspection Dept.</td><td colspan="5">Project Title: Job No.
Client: Contract No:
Contractor Contract No:</td><td colspan="2">Legend</td></tr>
<tr><td colspan="5"></td><td>X1 Hold Point
X2 Witness Point
X3 Record Review
QAS QA Surveillance</td><td>Note Certification Requirements
Note Any Other Requirements</td></tr>
<tr><td colspan="5">Author: Checked by: Approved by: Date</td><td colspan="2" rowspan="2">QUALITY PLAN
Number: Sheet</td></tr>
<tr><td>Rev.No/Date Revision</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
</table>

SECTION 15 - APPENDIX B

NOTIFICATION OF WORKS INSPECTION

To facilitate the handling of inspection notifications, the following procedure shall be observed.

At the commencement of all contracts, discussions shall be held with the Main Contractor's nominated representative and the Engineer to establish guidelines for the handling of inspection notifications and test documentation.

The Main Contractor shall prepare a notification form which shall include, but not necessarily be limited to, the following:-

1. INSPECTION NOTIFICATION NUMBER (IN)
2. PROJECT TITLE
3. MANUFACTURER AND FULL ADDRESS
4. WHERE TEST/INSPECTION WILL BE CARRIED OUT (IF DIFFERENT FROM 4 ABOVE)
5. ORDER/SUB ORDER NUMBER
6. CONTACT NAME
7. FAX/TELEPHONE NUMBER
8. DETAILS OF EQUIPMENT TO BE TESTED/INSPECTED AND WHETHER EQUIPMENT IS COMPLETE
9. SCHEDULE OF TESTS
10. MANUFACTURER'S APPROVED DRAWING NUMBER AND CORRESPONDING MEP NUMBER
11. DATE OF INSPECTION

The Main Contractor shall be responsible for recording all inspection notifications in numerical order and shall submit copies of the appropriate record at monthly intervals to the Inspection Department.

30 days notices of works inspection is normally requested.

SECTION 16

NATIONAL LOAD DESPATCH CENTRE (NLDC) CONTROL FACILITIES

CONTENTS

CLAUSE NO. TITLE PAGE NO.

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SECTION 16

NATIONAL LOAD DESPATCH CENTRE (NLDC) CONTROL FACILITIES

16.1 SCOPE

In order to provide the telecontrol facilities required at the NLDC the following provisions shall be made under this Contract.

All plant supplied under this Contract shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals. All required electrical quantities shall be transmitted to the NLDC through the Industrial Gateway of the substation automation system.

All HV breakers, motorized disconnectors, tap changer, etc. shall be controlled form NLDC through the Gateway of the substation automation system using IEC 60870-5-104 protocol. Cabling between the Substation Automation gateway and the communication equipment shall be included in this contract..

16.2 REQUIREMIENTS

16.2.1 Indications

The following indications shall be provided:

230kV and 132kV circuit breaker, disconnector and earth switch positions.

Transformer tap change selection on Auto/Manual.

Transformer tap position.

Control switches on Local/Supervisory.

Trip relays operated.

Auto-recloser on/off

16.2.2 Load Flows, System Voltage and Frequency

Electrical quantities shall be provided to enable the following measurements:

Power flow (MW and MVar) on all 230kV & 132kV feeder circuits and on the LV side of power transformers.

230kV and 132kV busbar voltages and frequencies.

230kV and 132 kV feeder voltages

16.2.3 Alarms

Alarm facilities shall be provided to alert the System Control Engineer at NLDC in the event of the following operations:-

Tripping of 230kV and 132kV circuit-breakers

Busbar protection operated

Feeder main 1 protection operated

Feeder main 2 protection operated

Feeder back-up protection operated

Circuit breaker fail protection operated

Feeder-end protection operated

Auto-reclose operated

Transformer protection operated (per transformer)

Transformer non-trip alarms (per transformer)

Transformer winding/oil temperature alarm (per transformer)

Tap change out of step alarm

Tap change incomplete alarm

Circuit breaker faulty alarm (e.g. low pressure)

Protection faulty alarm

Busbar protection faulty alarm

Battery fault (per battery)

Battery charger fail (per battery)

LV AC System Fail

Substation common alarm

Communication equipment alarm urgent

Communication equipment alarm non-urgent

Teleprotection channel fail.

Circuit breaker spring uncharged

Circuit breaker motor supply trip

Auto reclose blocked

DC supply failure

16.2.4 Controls

The following facilities shall be controlled from the NLDC.

230kV and 132kV circuit-breakers and motorised disconnectors

Trip relay reset

Auto-reclose in/out

Auto transformer tap change raise/lower

Tap change control remote/supervisory

Auto/non-auto voltage control.

16.3 INTERFACES

This contract includes Industrial grade Gateway to the NLDC. The Gateway shall have adequate capacity to cater to the future extensions of substation. The cabling between the Gateway and the communication equipment shall be provided under this contract.

SECTION 17

DRAWINGS

DRAWINGS

The following drawings shall form part of the Specification of the Bidding Document and shall be considered for tender purpose only. The drawings shall be finalized during detailed engineering after award of contract.

Drawing Number	**Title**
PGCB/Design/2018/FAR-BAR/E01	Layout of 230/132kV Faridpur S/S
PGCB/Design/2018/FAR-BAR/E02	Layout of 230/132/33kV Barisal (N) S/S
PGCB/Design/2018/FAR-BAR/E03	Single Line Diagram of 230kV GIS & 132kV AIS Faridpur S/S
PGCB/Design/2018/FAR-BAR/E04	Single Line Diagram of 230kV Barisal S/S
PGCB/Design/2018/FAR-BAR/E05	Protection Diagram of Transformer Bay
PGCB/Design/2018/FAR-BAR/E06	Protection Diagram of Line Bay
PGCB/Design/2018/FAR-BAR/E07	Protection Diagram of Bus Coupler Bay
PGCB/Design/2018/FAR-BAR/E08	Substation Automation System Architecture
PGCB/Design/2018/FAR-BAR/E09	LVAC Distribution Scheme
PGCB/Design/2018/FAR-BAR/E10	110 V D.C. Distribution Scheme
PGCB/Design/2018/FAR-BAR/E11	Single Line Diagram; DC48V Distributrion Scheme
PGCB/Design/2018/FAR-BAR/E12	Protection Diagram of One and half Scheme bay
PGCB/Design/2018/FAR-BAR/C01	Indoor GIS with Control Room Building layout
PGCB/Design/2018/FAR-BAR/C02	Ansar Barac Building Plan