

PART 2: EMPLOYER'S REQUIREMENTS

CHAPTER 13A: 220 kV RECEIVING

SUBSTATIONS

CONTENTS

1.1	Introduction.....	4
1.2	Power Source.....	4
1.2.1	BSPTCL Substation	4
1.2.2	BSTP Receiving Substation	4
1.3	Power Supply Characteristics:.....	5
1.4	General Technical Conditions	5
1.4.1	Environment and Climate Conditions	6
1.4.2	Vibration and Harmonics:	7
1.4.3	Protection against Corrosion	7
1.4.4	Creepage Distance and Clearance	7
1.4.5	Connection of Dissimilar Metals	8
1.4.6	Interlocking	8
1.4.7	Air Insulated Technology	8
1.4.8	Gas Insulated Technology	8
1.4.9	Design, Layout of Equipment and Arrangement.....	9
1.4.10	Ratings of various Equipment	9
1.4.11	Quality assurance.....	9
2.1	High Voltage Equipment.....	10
2.2.1	Scope of Work.....	10
2.2.2	Gas Charging	11
2.2.3	EOT Crane	11
2.2.4	Main Features Required.....	11
2.2.5	Governing Specifications.....	14
2.2.6	Tests	14
2.2.7	Earthing.....	15
2.2.8	Other Equipment	16
2.2.9	Transportation, Shipment and Storage.....	16
2.2.10	Type of Equipment	16
2.2.11	Technical Specifications	16
2.3	Air Insulated Type Switchgear (AIS).....	16
2.3.1	Circuit Breakers.....	16
2.3.2	Isolators.....	19
2.3.3	Current transformer	20
2.3.4	Voltage transformer	21
2.3.5	Outdoor Lightning Arresters	21
2.4	Outdoor Busbar	22
2.5	Switchyard Hardware (Clamps& Connectors).....	22
2.6	Auxiliary Mains Supply Equipment	22
2.6.1	Auxiliary Main Transformer	23
2.6.2	33 kV Gas Insulated Switchgear (GIS).....	
2.6.3	33 kV AIS Switchgear.....	41
2.6.4	33 kV / 415 V, 3 Phase Dry Type Auxiliary Transformers	47
2.6.5	Low Voltage Distribution Board (ACDB).....	48
2.6.6	110 V DC Power Supply System.....	48
2.6.7	Battery	50
2.6.8	Battery Charger cum 110 V DC Distribution Board	51
2.6.9	110 V DC Distribution Board	54
2.6.10	Cable Path.....	55
2.6.11	Accessory Boards	55
2.6.12	Clean Agent based Indirect Fire Suppression System	55

2.6.13	Safety Equipment	55
2.7	Traction Supply Equipment	56
2.7.1	Description	56
2.7.2	Traction Transformer	57
2.8	25 kV Switchgear	68
2.8.1	General Requirements	68
2.8.2	25 kV Circuit Breakers.....	69
2.8.3	25 kV Isolators.....	71
2.8.4	Lightning arresters.....	73
2.8.5	Indoor 25 kV Gas Insulated Switchgear (GIS).....	74
2.9	Instrument Transformers	77
2.9.1	General	77
2.9.2	Transformers	77
3.	PROTECTIONS CONTROL & MONITORING	79
3.1	General	79
3.2	High Voltage Protection.....	82
3.3	Transformer Protection.....	85
3.4	Bus Coupler.....	87
3.5	33 kV Protections	88
3.6	TRACTION PROTECTIONS	90
3.7	RELAYS	95
3.8	RELAY AND PROTECTION PANELS	99
3.9	SUBSTATION AUTOMATION SYSTEM.....	105
4.	CABLING	127
4.1	General	127
4.2	EHV 220/220/66 kV Cables.....	128
4.3	Medium Voltage 33 kV Cables	153
4.4	25 KV CABLES	164
4.5	3.3 KV CABLES	171
4.6	LOW VOLTAGE CABLES AND WIRING.....	174
5.	EARTHING.....	179
5.1	Earth Mesh Design 5.1.1 General	179
6.	METERING	187
7.	GENERAL ELECTRICAL WORKS	189
8.	CIVIL WORKS.....	190
9.	AMC: Refer DLP and Spare Policy attached with Preamble of BOQ	195
10.	SCADA Equipment Status	195

1. General

1.1 Introduction

Bangalore Suburban Metro Rail Company Karnataka (Bi-RIDE) has been authorized to execute the works for Bangalore Suburban Metro rail corridor for Bengaluru. The details of this section along with the expected date of opening for carriage of passenger and source of funding are as per ITT. The Proposed sites for RSSs cum TSS cum AMS are as under:

S. No.	RSS Location	Corridor	Corridor No.
1	Mathikere	KSR Bengaluru City-Devanahalli Benniganahalli - Chikkabanavara	Corridor-1&2
2	Benniganahalli	Benniganahalli - Chikkabanavara Kengeri- Bengaluru Cantonment Heelalige- Rajankunte	Corridor-2,3&4
3	Yelahanaka	KSR Bengaluru City-Devanahalli Heelalige- Rajankunte	Corridor-1&4
4	Soldevanahalli Depot RSS	Depot section only	Depot-1

1.2 Power Source

1.2.1 BSPTCL Substation

The following are the Source of power for the various RSS's.

No.	RSS Site	Feeder 1		Feeder 2	
		Source (KPTCL)	Approx. Distance from GSS to RSS	Source (KPTCL)	Approx. Distance from GSS to RSS
1	Mathikere	220kV Mathikere GSS	400 meters	220kV Peenya GSS	8 km approx..
2	Benniganahalli	220kV ITI GSS	5 km approx...	220kV HAL GSS	6 km approx....
3	Yelahanaka	220kV Puttenahalli GSS	1.2 km approx...	400/220kV Singanayakanahalli PGCIL GSS	6 km approx....
4	Soldevanahalli Depot RSS	220kV LILO from Neramangla to DB pura Line	4 km approx..	400KV PGCIL substation singanahalli	10 km approx

Note: The above-mentioned power sources and approx distance from GSS to RSS are indicative only. However, as per BoQ item no. 3.1.1, Detail Route Survey of complete Route Length along with making of trail Pits and making of final As built Drawing is in the scope of PST contractor.

1.2.2 BSTP Receiving Substation

At all the above BSTP Receiving Substations (RSS), the incoming High Voltage Supply will be stepped down to:

- 27.5 kV, single phase and will be fed to the traction overhead equipment, through a Traction Substation (TSS), located in the same premises as the RSS.
- 33 kV, three phase and will be fed to the 33 kV Auxiliary Network and the Auxiliary substations, to meet the Auxiliary power demand at stations and en-route, through an Auxiliary Main Substation (AMS), located in the same premises as the RSS.

1.3 Power Supply Characteristics: -

Nominal Voltage	220kV	132kV	66kV
Max. Voltage Variation	+10%,-15% of rated value	+10%,-15% of rated value	+10%,-15% of rated value
Nominal Frequency	50Hz	50Hz	50Hz
Max. Frequency	±3%	±3%	±3%
Short Circuit Current	40kA for 1sec unless otherwise specified in specifications	31.5kA for 1sec unless otherwise specified in specifications	20kA for 1sec unless otherwise specified in specifications

1.4 General Technical Conditions

Unless indicated otherwise herein, all equipment supplied and installed shall comply with the International Electro technical Commission (IEC) standards, or equivalent Indian standards.

The supply shall include all supporting structures, embedded parts, auxiliary equipment, mechanical linkages, hydraulic piping for control devices with pumps, auxiliary circuits wiring, interlocking devices, current and voltage transformers, cable end-boxes. The necessary sub-assemblies must be assembled in the PST contractor 's plant, taking into account the transportation conditions. The Terminal Board for the output (control supply) of all panels (CB, LBS, Isolator, Battery Chargers etc.) shall be factory fitted only. Complete safety to personnel during operation and ease of maintenance shall be ensured. The PST contractor shall study the quality of power supply network and supply of equipment accordingly, failure of any equipment due to poor power supply quality i.e. surges etc. shall be responsibility of the PST contractor. The equipment characteristics are given in the technical sheets.

Wherever, an alternative arrangement of any equipment/material is given anywhere in the specifications then the Engineer's decision for use of any equipment/material shall be final without any cost implication to BSTP.

The scope shall include all activities to make the units fully functional and to meet the requirements of power supply arrangement. This includes but not limited to supply and erection of equipment, foundations of all equipment, all cables, connectors, supporting structures, necessary equipment, small part steel & other components required to make system fully functional. HV Bus bar gentry structure shall be made by HPI and tubular poles.

Only hot-dip GI pipe/sheets/nuts/bolts etc. shall be used in the RSS work, nowhere M.S pipe/sheet/nut/bolts etc. shall be allowed.

All necessary steps shall have to be taken by the PST contractor and requirements fulfilled so as to obtain the green building Certification (IGBC certification with Platinum rating) for RSS building. All preparation of documentation for IGBC certification for RSS is in the scope of RSS PST contractor. (Details attached as Annexure-A1) The equipment, process, design shall be meeting these requirements and is in the scope of contract and included in bid.

Note:

1. PST contractor shall conduct the soil investigation study and provide for ground improvement works (if any).

1.4.1 Environment and Climate Conditions

In general, all equipment and assemblies shall be suitable for outdoor use in dry arid and also tropical climates and in areas having heavy rainfall, pollution due to industry and coastal environment and severe lightning. The limiting weather conditions, which the equipment has to withstand in service, are indicated below:

The manufacturer shall take a note of the ambient air pollution prevailing in Bengaluru as per IEC 60721-3-3 suitable for urban area, therefore, PST contractor shall examine the level of harmful gases and all electronic cards used in IEDs, Relays, Breakers, Invertors, Battery Chargers/DCDB, PLC, AVRs and to provide conformal coating on each card accordingly to protect to the failures due to environment conditions.

A certificate to this effect shall be submitted before delivery of material.

S. No.	Parameters	Value
1	Maximum Ambient Air Temperature	As per GS
2	Minimum ambient air temperature	As per GS
3	Maximum relative humidity	As per GS
4	Annual rainfall	As per GS
5	Number of thunderstorm days per annum	As per GS
6	Number of dust storm days per annum	As per GS
7	Number of rainy days per annum	As per GS
8	Maximum basic wind pressure	As per GS
9	Altitude above m.s.l (max)	As per GS
10	Pollution level	Very Heavy as per IEC 815-1986 & IS 13134-1992

All applicable Cards must have also tested for Environmental Tests as per IEC 60571 and shall be done in accordance to IEC 60068. Details of test are mentioned below:

- (i) Dry Heat Test
- (ii) Low Temperature Test (in case applicable for Bengaluru ambient temperature range)
- (iii) Change of Temperature Test
- (iv) Damp Heat Test

(v) Driving Rain Test

The prior approval for specifications and makes of all components and subcomponents like relay, cards, capacitors etc. of the equipment shall be obtained from the Employer. The PST contractor s shall submit details of configuration in the card, block diagram of the cards and waveform signature for each electronic card used in the equipment along with O&M documentation.

1.4.2 Vibration and Harmonics: -

The transformer installation would be subject to vibrations on account of passage of trains on nearby tracks. The AC electric locomotives are fitted with VVVF type IGBT controlled Converter-Inverter (CI) for feeding the 3-phase AC Traction Motor.

The converter-inverter introduces harmonic currents in the 25 kV power supply system.

Harmonics	With IGBT
3 rd (150 Hz)	Overall 2%
5 th (250 Hz)	
7 th (350 Hz)	
9 th (450 Hz)	
11 th (550 Hz)	

1.4.3 Protection against Corrosion

All outdoor cubicles, marshaling kiosks, control & protection cable terminations boxes should be made of stainless-steel sheet of 2 mm thickness AISI 316 and must be suitable for outdoor applications with IP-55 level of Ingress protection. All BMK should be stainless steel and only one key (square key) shall be used to assess all equipment.

All steel structure (lattice type) shall be galvanized as 1000 gm/sqm. while pipes with 610 gm/Sqm as per latest relevant RDSO specifications suitable for Very heavy pollution as per IEC 60815 & IS 13134-1992. All ferrous part of equipment shall have galvanization 1000 gm/Sqm. The nut and bolts shall be galvanized as per the relevant IS.

1.4.4 Creepage Distance and Clearance

Creepage distance for all equipment shall be 31 mm/kV suitable for very heavy pollution as per IEC 60815 and CEA regulation rule-43. Clearance (mm) between equipment live part to earth shall be as mentioned below:

Sl.	Description	25kV	33kV	66kV	132kV	220kV
1.	Between Phases (in mm)	-	320	630	1300	2400
2.	Between one phase and earth for rigid conductor (in mm)	500	320	630	1300	2100
3.	Between any point where man may be required to stand on the nearest					
a.	Unsecured Conductor in air (in mm)	3000	-	3500	4000	5000
b.	Secured Conductor in air (in mm)	2000	-	-	-	-
4.	Minimum height of Bus Bar (above foundation top) (in mm)	3800	-	4600	4600	5500
5.	Safe Working Clearance (in mm)	2000	2800	3100	3700	4300

1.4.5 Connection of Dissimilar Metals

In general, all connections between dissimilar conducting metals i.e. steel & Copper, Aluminum & Copper, Steel & Aluminum or any other combination should be provided with suitable bimetallic connection of thickness not less than 2 mm.

1.4.6 Interlocking

PST contractor shall be required to develop interlocking scheme based on the best prevalent engineering practices for all the HV, LV switchgears and equipment in RSS, AMS & TSS. The interlocking scheme shall be developed keeping into view of interlocking provided in BSTP substations and shall be submitted to BSTP for approval along with SLD.

1.4.7 Air Insulated Technology

The High Voltage bays in the Receiving Substations shall be built according to Air Insulated Technology, unless otherwise specified.

The High Voltage Circuit Breakers and Current Transformers are of SF-6 gas insulated technology. They shall comply with the outdoor type requirement. The manufacturer shall check and certify that the equipment characteristics mentioned herein are suited for the network characteristics, if necessary, in consultation with the Power Supply Authorities viz. BSPTCL.

The proposed tentative layout is shown on the enclosed drawings. The PST contractor may try to optimize the layout, if considered necessary, without compromising on the electrical clearance, accessibility to equipment inside the RSS, safety requirements and provisions for future. The layouts shall be subject to approval by the Employer and shall not have any functional implications. The manufacturer shall also have to let know his previous experience in the field of 220kV/132kV/66 kV SF6 gas insulated apparatuses for air insulated substations.

1.4.8 Gas Insulated Technology

The High Voltage bays in the Receiving Substations shall be built according to Gas Insulated Technology (GIS), unless otherwise specified. They shall comply with the requirements specified in clause 2.

The PST contractor may try to optimize the layout, if considered necessary, without compromising on the electrical clearance, accessibility to equipment inside the RSS, safety requirements and provisions for future. The layouts shall be subject to approval by the Employer and shall not have any functional implications.

The manufacturer shall also have to let know his previous experience in the field of 220kV/132kV/66 kV or above GIS substations.

1.4.9 Design, Layout of Equipment and Arrangement

The apparatuses shall be installed according to the group phase layout, whereby the three phases of each circuit are installed side-by-side and advance function-by-function. The architectural configuration of the station shall make it as compact as possible with clear and logical layout of the bus-bars, facilitating, in addition, accessibility to all actuating devices and possible extensions to accommodate equipment to be installed subsequently. The means of access to the various equipment for the maintenance staff shall be safe

The maintenance personnel shall have access to and shall be capable of moving freely around each element in the cubicles. The equipment may be supported on metal frames. These frames shall not hinder access to any part of the station, nor handling, overhauling, and assembly operations. All the relevant statutory guidelines for various clearances shall be complied while developing the layout.

1.4.10 Ratings of various Equipment

The rating of various equipment mentioned in the specifications is indicative. The PST contractor has to verify the design and if the requirement of rating so arrived is more through design than as specified then, equipment of more rating shall be provided by the PST contractor. The cost of this is deemed to be included in the bid.

The design shall also comply all the statutory requirements as per the CEA notification on regulations for Measures relating with Safety and Electric Supply 2010 (IE Rules). The bid is deemed to include the cost for all such provisions.

The bidder has to make the system functional smoothly and shall provide all the required ancillaries wherever required like ladders, safety items, assisting tools, special maintenance tools recommended by OEM of the equipment for the smooth functioning of the system.

1.4.11 Quality assurance

The PST contractor shall prepare and submit quality assurance plan for manufacturing of Equipment supplied under the contract in consultation with the Employer. Due care shall be taken to avoid manufacturing defects such as voids in cast resin / porcelain equipment like CT, PT, Dry Type transformer, CB, Insulators etc. The Quality Assurance plan shall be submitted along with the Vendor Proposal.

All Isolator shall be selected from RDSO approved vendor list only.

2. SUB-STATION EQUIPMENT SPECIFICATION

These specifications are generalized for incoming voltage level 220kV/132kV/66kV. However, the bidder shall bid tender as per voltage level mentioned in the BOQ.

All switchgear, equipment, bus bars, jumpers, HT cables etc. shall be designed based on the overloading capacity of the Traction transformers and Auxiliary Main transformer. However minimum rating will be as specified in the specifications. The sub-station equipment are classified into following sections: -

2.1 High Voltage Equipment

High Voltage Equipment located within the premises of the Receiving Substation (RSS) performs the task of supplying 220 kV, 3-phase power supply to the 33 kV distribution network and 1-phase 25 kV Traction power supply to OHE, through appropriate switchgear, Isolators, lightening arrestors, Measuring & Protection arrangements. The High Voltage Equipment mainly comprises of:

2.2 EHV Gas Insulated Switchgear (GIS)

2.2.1 Scope of Work

The scope of work comprises of shop testing, supply, delivery at site, installation, testing and commissioning of 3-phase, 220kV Rated voltage 245kV, 2000A at 40°C, 40kA for 3 Sec, Double Bus Bar Gas insulated indoor type receiving sub-station. The supply will include all supporting structures, auxiliary equipment, mechanical linkages, hydraulic piping for control devices with pumps, SF6 gas piping, auxiliary circuits wiring, interlocking devices, current and voltage transformers, cable end boxes and SF6 bus ducts. Necessary sub-assemblies must be assembled in the supplier's plan, accounting for the transportation condition. The scope of work includes the following (but not limited to):

(A) For RSS:

I. Each Incomer Bay (2 Nos.) consisting of:

- Circuit Breaker – 1 No.
- Current Transformer – 1 No.
- Line Disconnecter with Maintenance Earth Switch – 1 No.
- Line Earth Switch (Fast acting) - 1 No.
- Voltage Transformer with motor operated isolation device of rated insulation
- Indoor lightning arrestor with surge arrestor counter on GIS and having SCADA communicability on IEC 61850 protocol
- Bus Disconnecter with Earth Switch – 2 Nos.
- Bus end Maintenance earth Switch – 2 No.
- Other items as required for connection to the two bus bars, 220/132/66 kV incoming cables as applicable through lightning arrestor and for completing the intent of work

II. Each Transformer Feeder Bay (4 Nos.) consisting of:

- Circuit Breaker – 1 No.
- Current Transformer – 1 No.
- Maintenance Earth Switch (Tr. Side)-1 Nos.
- Bus Disconnectors with Earth switch – 2 Nos.

- Indoor lightning arrestor with surge arrestor counter on GIS and having SCADA communicability on IEC 61850 protocol
- Other items as required for connection to bus bars, cables, lightning arrestor etc. and for completing the intent of work

III. Each Bus Coupler Bay (1 No.) consisting of:

- Circuit Breaker – 1 No.
- Current Transformer – 2 Nos.
- Bus Disconnectors with Earth Switch – 2 Nos.
- Other items as required for connection to bus bars, cables etc. and for completing the intent of work

IV. Each Bus consisting of:

- Voltage Transformer with motorized isolation device of rated insulation- 1Nos
- Bus Earthing Switch – 1 No.

2.2.2 Gas Charging.

New gas charging equipment with gas cylinders for each set of the newly constructed GIS substation is covered in the scope of work – After commissioning this will become property of the Employer. The PST contractor would be required to handover them in proper working condition with enough gas for one charging of complete system.

2.2.3 EOT Crane

EOT crane with VVVF drive for GIS equipment handling during installation, commissioning and maintenance etc. shall be provided at each 220/132/ 66kV GIS substation. The EOT crane lifting capacity shall be adequate to handle the heaviest package of GIS but shall not be less than 5 tons. For detailed specifications and scope refer ANNEXURE- A8

2.2.4 Main Features Required

- 1) All voltage level GIS equipment shall be built according to the SF6 gas insulation technology.
- 2) All voltage level GIS as offered should be fully type tested as per latest IEC standards at the time of vendor approval and type test report should not be more than 5 years old at the time of **post bid vendor / make approval**.
- 3) The equipment installed shall offer all necessary facilities for equipping and connecting the equipment sections to follow, without entailing any shut down of equipment already in service.
- 4) In the event of arcing in a compartment, the arcs should not extend to the neighboring compartment. Any failure to the enclosure of the compartment shall not lead to damages in the neighboring compartments.
- 5) Suitable means of expansions should be provided in the metal enclosure and pipelines to absorb the actual thermal expansion and contraction of the SF6 equipment and to facilitate the alignment of switchgear assembly.

- 6) The metal enclosures for the SF6 gas insulated equipment modules shall be made from aluminum alloy.
- 7) Internal insulation level between live parts and earth when the pressure of the gas goes to the atmospheric pressure should not be less than $1.2 \times 132 / 1.732$ kV OR $1.2 \times 220 / 1.732$ kV.
- 8) GIS should be of modular design, and it should be possible to add feeder bays for two additional incomers, if required on either end without any drilling, cutting or welding on existing equipment and without the necessity of moving or dislocating the existing switchgear bays. The layout of GIS equipment and transformers should show space earmarked along with suitable cut outs for the future provision. Future expansion manual shall be submitted along with vendor proposal. Bidder to consider future provisions for building design for one bay as per tender document/drawing
- 9) 4-20mA output is necessary for SCADA communication.
- 10) GIS supplier should have minimum 5 years' experience in design and manufacturing of similar GIS substations. This shall be explained in tenderer's technical proposal. The tenderer will be required to explain availability of spares and service from technically trained manpower.
- 11) The incoming 3 phase 220/132/66 kV, 2 runs single core cable feeders can be of minimum size of 630 mm² to 1200 mm². The termination arrangement shall however be designed for two such cables, so that additional cables can be terminated later, if required. The outgoing connections from GIS shall be in gas filled enclosure, designed in such a way that vibration from GIS equipment and transformer are not transmitted to each other. The transformer feeder bays should have termination arrangements suitable for cable cross-section required as per current requirements of transformer.
- 12) The Disconnectors and Earthing Switches shall be electrically and mechanically interlocked against mal-operation. Feeder earthing switch shall be fast acting type with making capacity and isolated from earthed enclosures and shall permit testing of switchgear.
- 13) The conductors/bus bars shall be of Aluminum and enclosure shall be made of Aluminum Alloy.
- 14) All gas sampling shall be possible during normal operation and without loss of gas.
- 15) The gas barrier insulators shall withstand 1.5 times maximum rated pressure on one side and vacuum on the other side. All fixtures or nuts or instruments whose maintenance / opening would leak the SF6 gas should be clearly ear marked and distinctly identifiable.
- 16) Loss of gas per annum shall not exceed 1% by weight in each compartment.
- 17) Adequate burden capacity shall be available in instrument transformers to permit provision of additional test, protection on measuring instruments. The instrument transformer shall have separate metering cores to permit measurement of values of energy, power, current and voltage as per required accuracy, giving due consideration to the fact that load during initial stages may be much lower than designed capacity. All current transformers shall have a 3-second short-time current rating of not less than the maximum System fault level. The technical details viz. burden capacity, knee voltage and turn ratio of the instrument transformers shall be finalized before manufacturing clearance of the GIS (the calculations shall be submitted during vendor / technical approval using all the available actual data). The burden capacity shall be designed keeping in mind at least 40% spare capacity for future requirements. The instruments shall also be sized and positioned so that a 5'-5'-6" height operator can read the instrument without additional support.

- 18) Clear visual indication of isolator and earthing switch, switch blade position, whether open or closed shall be provided.
- 19) Each component shall be modular and complete with ancillary equipment. The design shall be such that all parts subject to wear and tear are easily accessible for maintenance purpose. The equipment shall be protected against all types of voltage surges and shall necessarily include any component or assembly required for this purpose.
- 20) Circuit breaker shall be of single pressure interrupter. The moving and fixed contacts shall be housed in the same interrupter chamber without any split so as not to affect the synchronism of three phases. The Operating Mechanism for the circuit breaker shall be Spring/Spring or to give highest reliability to the system, following loss of supply voltage the operating mechanism shall have local storage sufficiency for a duty cycle of O-CO without the need for recharging. The rated duty cycle of the circuit breaker shall be O-0.3s-CO-15s-CO. The circuit breakers shall be provided with an "anti-hunting" coil for all commands going to the switchgear. All interlock and automatic systems within the actuation system shall be designed so that the circuit breaker executes operations only when it is in a position enabling to do so completely and reliably.
- 21) The isolators shall be fitted with a suitable actuation system operating simultaneously on all three poles, backed up by an emergency manual actuation in case of malfunction of the former. The isolators shall not change of position under the effect of electro dynamic loads. There shall be hard-wire interlock between isolator, circuit breaker and earth-switch.
- 22) In case of any internal arc fault – regardless of whether it occurs in a bus bar section, a busbar isolator or the circuit breaker-repair works should be possible without shutting down the substation; at least one busbar and the undisturbed feeder should remain in operation. It should be possible to remove and replace a fully assembled circuit breaker without interfering the operation of the adjacent feeder. All circuit breakers should be interchangeable.
- 23) The GIS equipment shall be arranged in such a manner that in case of maintenance work on any of the equipment, at least one bus bar should be available for operation.
- 24) Each bay shall be segregated from its neighbor bays by means of gas tight barrier insulators to ensure that in case of an internal arc the fault will be restricted to the concerned bay.
- 25) The Conventional Local Control Cubicles shall be integrated with the GIS with hard wire interlocking. Provision of SCADA permissive shall also be present.
- 26) Following accessories shall be provided for each compartment.
 - Pressure relief devices.
 - Provision of desiccants.
- 27) Monitoring of Gas in the enclosure:

Each gas compartment should have its own SF6 pressure monitoring facilities as well as static filters. Pressure relief devices shall be designed to limit maximum pressurize below the busting level of the enclosure and barrier insulation. Instruments communicable to SCADA shall be provided to continuously monitor the Gas density.

- 28) The protection devices for this equipment shall ensure permanent monitoring of gas pressure inside each compartment by means of temperature compensated monitoring devices triggering a dual alarm threshold annunciation system in the event of gas pressure

drops:

Stage 1: Performance of the station is unaffected, in particular cut-off capabilities remain intact. Immediate intervention by the specialist is not necessary but recommended.

Stage 2: The dielectric properties of the station in the presence of occurring over voltage shall be such that all the necessary isolating operations still remain possible without any danger or any accident taking place. In case of drop of pressure below minimum level, the concerned breaker should trip and then lock. The inter bay width shall be sufficient to allow access to all drive mechanisms and other termination boxes without the need of dismantling other apparatuses.

- 29) The design of the cable termination shall allow plugging and unplugging the HV cable without need of opening the GIS and without any gas work. Training & competency for cable termination in GIS shall be provided to nominated BSTP/BSTP staff.
- 30) All ratings and requirements not covered in this part but furnished earlier in this specification in regard to circuit breakers, isolators, earthing switches and instrument transformers also apply to GIS equipment.
- 31) There should also be provision of manual PT disconnection handle (outside GIS) for PT isolation.
- 32) There shall be provision for testing Lightning arrestor and surge counter separately to ascertain proper working during service life.

2.2.5 Governing Specifications:

The complete GIS equipment shall meet the requirements of latest versions of IEC/International standards/specifications, a few of these are indicated below:

CENLEC EN 62155/IEC 62155	Standards for pressure vessel construction
IEC 62271-203	Gas insulated metal enclosed switchgear for rated voltage of 72.5 kV and above
IEC 62271-1	Common specifications for high voltage switchgear and control gear standards
IEC 60137	Insulated bushings for alternating voltage above 1kV
IEC 61869	Instrument transformers
IEC 62271-100	High voltage alternating current circuit breaker
IEC 62271-102	AC Disconnecter and earth switch
IEC 60480	Guide to checking of SF6
IEC 61634	Use handling of SF6
IEC 60859	Cable connector for GIS
IEC 60099	Surge Arrestor/LA

2.2.6 Tests

- a) The modules individually as well as the assembly shall be subject to various test, including type test, as required in terms of provisions of Chapter – 9 of “Employer’s Requirements. General Specifications” prior to shipment. In case valid type test reports from an independent lab are not available (not older than 05 years at the time of **post bid vendor / make approval**).

the type tests shall be conducted by the PST contractor which shall be witnessed by employer's representative. The cost of testing shall be borne by the PST contractor .

- b) Site tests shall include leakage tests, moisture contents in dielectric and power frequency test to ensure conducting particles present in the Gas are below permissible limits. These limits shall be furnished by the PST contractor .
- c) The indicative list of tests is given in chapter **13C** of this PS.

2.2.7 Earthing

Entire metallic enclosure shall be bonded together and effectively earthed as per manufactures recommendations.

2.2.8 Other Equipment

Main intake power transformers, Earthing system, lighting protection, illumination arrangement etc. Shall comply with the relevant stipulations of Outdoor type RSS. The control, monitoring, logging etc. shall be identical to the outdoor type RSS.

2.2.9 Transportation, Shipment and Storage

Transportation, shipment and storage of GIS equipment shall be as per international practice/standards. The manufacturer shall provide detailed installation procedure along with installation timeline for proper planning of installation activities. The PST contractor shall coordinate and arrange all the required tools and equipment for the installation of GIS at site

2.2.10 Type of Equipment

The 220/132/66 kV and 25 kV equipment shall be of GIS/AIS type while 33 kV side equipment will be GIS/AIS type and housed inside AMS building. These will be as per specification indicated elsewhere in the tender.

2.2.11 Technical Specifications

For detailed technical specifications, please refer Technical Data Sheets provided in Chapter-13B. The relevant portions in those sheets shall be filled by manufacturer / PST contractor and submitted with vendor proposal.

Sl.	Description	66kV	132kV	220kV
1.	Enclosure Type	Three Phase Enclosure		
2.	Rated Voltage (in kV)	72.6	145	245
3.	Rated Frequency (in Hz)	50	50	50
4.	Rated Current of Bus Bar (in A)	2000	2000	2000
5.	Rated Insulation			
a.	Power Frequency withstand rms Voltage (in kV)	140	275	395
b.	Lightning Impulse withstand voltage, peak (in kV)	325	650	950
6.	Rated short time current rms,3 sec (in kA)	20	31.5	40

7.	Guaranteed SF6 gas losses per year	Less than 1%
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2.3 Air Insulated Type Switchgear (AIS)

Creepage distance for all the equipment shall be 31 mm/kV. Fault duration for all equipment shall be taken as 3 sec.

All switchgear, equipment, busbars, jumpers, HT cables etc. shall be based on the overloading capacity of the Traction transformers and Auxiliary Main transformer. However minimum rating will be as specified in the specifications.

This covers the specifications of various equipment used in outdoor type RSS are as under:

2.3.1 Circuit Breakers

i) Governing Specification

The 220 kV/132kV/66 kV Circuit Breakers shall conform to IEC 62271-1 and IEC 62271-100 **(C2-M2 class compliant/RDSO approved)**. The electro-technical characteristics required to be guaranteed for circuit breakers of different voltage levels, are shown in the Technical sheets (see Chapter 8B).

ii) SF-6 type

The circuit breaker must be SF-6 puffer type and single pressure type with only one breaker per pole, mounted on one insulated support column. The operating mechanism shall be spring-spring type. The auxiliary supply for spring charging motor shall be suitable for 110V DC.

The Circuit Breakers shall be fitted with an electrical actuation system operating simultaneously on all three poles, backed-up by an emergency manual actuation in case of malfunction of the former.

The moving contact shall be equipped with different compartment allowing a rise of pressure which shall be used to extinguish the arc and assist the opening movement, in order to avoid poles deterioration and to reduce the actuation energy required to operate the CB. It shall be possible to lock the manual actuating device in open position by means of key and lock system.

iii) Anti-hunting coil

An "anti-hunting" coil is required on all commands going to the switchgear. This function prevents execution of two successive closing if the first one is immediately followed by a trip-out that is to say if the first closing is not successful.

This prevents the circuit breaker from re-closing and from hunting until any opening order is given to confirm the tripping. Then a new closing order could operate.

iv) Under-voltage coil

2 nos. of 110 V DC auxiliary under-voltage trip-out coil with separate MCBs are required in all circuit breaker with approved means.

v) Interlocking

All interlocks and automatic systems within the actuation system shall be designed so that the circuit breaker executes operations only when it is in a position enabling to do so completely and reliably. That mean, for example, when an apparatus is in remote control, the local control does not operate.

vi) Control system

The PST contractor shall provide a detailed description of the pneumatic or spring system used to operate the circuit-breaker, their rated supply pressure, lower and higher acceptable pressure limits and thresholds together with the maximum number of consecutive actuation possible while still enabling correct operation.

Each pole shall be mechanically connected by means of a link and a transmission assembly to the operating mechanism. The energy needed for the opening and the closing operations shall be supplied by different springs located in the control cubicle. It shall be possible to reload the springs manually by mean of handle.

The control cubicle shall include a remote/local changeover switch and opening and closing push buttons. The close Push buttons shall be active in local mode and inactive in remote mode. The open bush button to remain active in all modes

CB control boxes shall be PU painted or with better rust protecting material with Minimum IP 65 class and suitable for outdoor application and the life of control box shall be matched with life of equipment and shall include an anti-condensation heating. Appropriate Test for Rust protection as per relevant standards to be submitted.

An optical indicator shall indicate:

- the position of the circuit breaker (Closed or open) with Red & Green LED indication
- the position of the closing spring (Loaded or unloaded)

vii) Operating duration

The operating cut-off, opening and closing duration shall comply with the standards in force (IEC 62271-1, 62271-100). All three poles shall open and close simultaneously. In case of any mechanical out of synchronization in the operation of the three poles it shall at least fall within the tolerances stipulated in the standards in force.

The rated lightning impulse withstand voltage when circuit breaker gap open should be 950 kV for 220 kV, 650 kV for 132 kV and 325 kV for 66 kV.

viii) SF6 pressure protection device

The protection devices for this equipment shall ensure permanent monitoring of gas pressure inside each compartment by mean of temperature compensated monitoring devices triggering a dual alarm threshold annunciation system in the event of gas pressure drops.

a) Initial alarm threshold

- Performance of the CB is unaffected, in particular breaking capabilities remain intact.
- Immediate intervention by specialist is not necessary.

b) Second alarm threshold

- CB tripping and locked until SF6 refilling
- Isolating capabilities of the CB remain intact.
- Immediate intervention by specialist is necessary.
- Control orders are inactive.

c) Devices

The devices used must provide full reliability and operating safety and not represent a weak spot for the tightness of equipment. At no time shall these devices indicate any wrong data, not lose their accuracy regardless of ambient temperature or of the operating incident concerned. This is why monitoring devices with temperature compensation are specified.

Each gas compartment should have its own SF6 pressure monitoring facilities as well as its static filters. Pressure relief devices should be designed to limit maximum pressure rise below the bursting level of the enclosure and barrier insulation but not designed to retain the fragment of bursting disk. All gas compartments shall be equipped with rupture diaphragms to prevent the enclosure from uncontrolled bursting.

d) Testing and Inspection Devices

Each compartment will be equipped with valves and connections enabling gas to be added or direct readout pressure measuring equipment to be fitted while the equipment is energized.

The various joints and gaskets shall ensure full tightness and be protected so as to withstand the effects of the various corrosive agents present in the atmosphere (pollution, temperature, humidity, etc.). The corresponding flanges shall be fitted with an effective system for testing sealing all leaks even very slight ones that may occur around or because of these joints.

The apparatuses shall be fitted with pressure release valves with deflectors to ensure protection against overpressure. Test certificates of this device shall be supplied.

ix) Earthing system

Each circuit breaker shall be equipped with an earthing connecting device, on upstream and downstream side, to earth the isolated circuit.

2.3.2 Isolators**i) Governing Specification**

All isolators shall conform to IEC 62271-1, 62271-102. The electro technical characteristics required to be guaranteed for isolators of different voltage levels are shown in the technical sheets (see Chapter 8B).

ii) General

The isolators shall be fitted with an electrical actuation system operating simultaneously on all three poles, backed-up by an emergency manual actuation in case of malfunction of the former. The actuating device shall be capable to be operated electrically or manually through a changeover switch with three positions (off / manual / electrical) provided on the motor box.

The isolators shall not change of position under the effects of electrodynamics loads, which may occur during operation, in particular those caused by short-circuits.

The isolators shall be of two-column rotary center break type, with two moving parts (two rotating columns). They shall be protected against corona discharge by providing metallic ring. The control cubicle shall be of stainless-steel dust and waterproof (IP 55) suitable for outdoor application and shall include an anti-condensation heating.

iii) Line Isolator

The line isolator (LIS-x) shall be equipped with earthing isolator (LEIS-x) to earth the cable from BSPTCL. This earthing isolator shall be mechanically interlocked with the line isolator LIS to lock the open apparatus when the other one is closed.

The electrical operation of LEIS-x shall be available only locally with motor operated and interlocked with the voltage lock on the cable and with the open position of up and downstream circuit breakers. That mean it shall be impossible to operate the LEIS-x, when the cable is charged.

The manual operation shall be subject to the local locking by padlock.

iv) Earthing system

Each isolator shall be equipped with an earthing connecting device, on upstream and downstream side, to earth the isolated circuit by mean of a device interconnecting and earthing the three phases.

The line isolators (LIS-x), being equipped with an upstream earthing isolator, shall have only a downstream earthing connecting device.

2.3.3 Current transformer

The current transformers shall be Oil insulated live tank type. That means the core with the secondary winding is housed in the top tank which is LIVE. In Live Tank, the core and secondary winding is insulated against the high voltage and housed in the top live tank. primary and secondary are enclosed into a chamber full of oil to ensure isolation between both winding and to reduce the dimension of the active part.

Each incoming section shall be equipped with measuring and protection current transformer on each phase. Each transformer section shall be equipped with protecting current transformer on each phase, that is to say 3 current transformers for the auxiliary transformer section and two current transformers for the traction transformer section. The coupling section shall be equipped with a set of three protection current transformers, one on each phase.

2.3.4 Voltage transformer

The voltage transformers shall be of capacitive type. Each incoming section shall be equipped with voltage transformer on each phase. The coupling section shall be equipped with a set of three voltage transformers on each half-bus bar.

The high voltage capacitor and intermediate capacitor shall consist of series connected capacitors. Each element shall be made of high purity cellulose paper or paper-polypropylene and aluminum sheets or foils forming electrodes. The oil seal shall be ensured by rubber gasket unaffected by oil or ambient pollution.

Extension of oil, due to temperature variations, shall be ensured by an elastic diaphragm also unaffected by oil. Alternatively, stainless steel bellows are acceptable. The electromagnetic element, MV transformer and series inductance, shall be located in a hermetically sealed tank filled with oil.

The electromagnetic part shall be equipped with a protection against over-voltage and iron resonance phenomenon. The low voltage terminals, mounted on the tank, shall be made on an insulated epoxy resin containing the secondary terminals and the fuse-holders. The ground terminals can be provided outside the secondary terminal box.

Anti-condensation heating arrangement may be provided inside the Low Voltage terminal box. If anti-condensation heating is not provided, suitable 'breathers' have to be provided to remove moisture, if any. The insulator shall be fastened to the tank by mean of a metal flange, which shall be bonded to the porcelain.

The insulator leakage path shall be 31 mm/kV. The outer metallic parts, tank, base, head and flanges, shall not require any maintenance.

2.3.5 Outdoor Lightning Arresters

Each phase of the primary side of each transformer and incomer shall be equipped with polymeric Lightning arrestors as per IEC 60099-4 and IS 3070 part 3. The Lightning Arrestor should be blast proof. These are made to protect the transformers against operating over-voltage and, eventually, against lightning impulses. For this reason, they shall be installed immediately upstream the transformer primary connection. They shall be zinc-oxide types and they shall contain a single of resistor, which active part shall be composed of perfectly homogeneous resistors. The polymeric enclosure shall be with long Creepage distance to ensure good insulation with a high-level pollution cage or wrap type construction with no gas volume to ensure that the arrester does not explode during the short circuit test condition. They shall correspond to the class discharge 4 of the IEC 600994. (Minimum discharge capability – 10.8 kJ/kV).

A surge counter shall be SCADA communicable type, which shall be integrated with BSTP SCADA installed on each lightning arrester to indicate the number of functioning of each device. They shall also indicate the value of the leakage current. The Surge Counter shall be electronic type, compatible with all makes of surge arrestors. The surge arrestors shall not have any metal oxide blocks which can degrade during usage and add additional residual voltage.

Surge arrester shall be capable of discharging energy equipment to class 4 of IEC for a 220/132/66 kV system on two successive operations followed immediately by 50Hz energization with a sequential voltage profile as specified in TOV characteristics: -

S. No.	Voltage	1 Sec	10 Sec	100 Sec
1	220 kV	234 kV	225 kV	214 kV
2	132 kV	117 kV	113 kV	107 kV
3	66 kV	70.8 kV	68.4 kV	64.8 kV

(Details of sequential voltage profiles are as per IEC)

They shall be well insulated and shall be suitable for outdoor use. All type tests and routine tests of Lightning Arresters as per relevant IEC standards as specified in technical specifications shall be carried out if valid report not available. The type test reports should not be more than 5 years old at the time of **post bid vendor / make approval**

There shall be provision for testing Lightning arrestor and surge counter separately to ascertain proper working during service life.

2.4 Outdoor Busbar

The main bus bars shall be realized with rigid aluminum tubes, with suitable design, or with higher size to cater the design load of bus bar. Main bus bar shall be supported on polymeric high post insulator (HPI) as per relevant IEC. The bus bars and the connection to the apparatuses shall be realized as strung bus with a double tension adjuster set made of polymeric material. The strung bus conductor shall be Aluminum tube or higher, as required.

2.5 Switchyard Hardware (Clamps& Connectors)

Clamps and connectors (For connecting to equipment terminals and conductors) shall be of aluminum alloy casting type A6 as per IS 617 or equivalent. In case of copper terminals, the clamps and connectors shall be of 2mm thick bi-metallic liner/strip. Clamps, connectors and joints shall be design for 1.5 times current carrying capacity of rated equipment/bus bar current as per IS 5561 and relevant standards.

2.6 Auxiliary Mains Supply Equipment

Auxiliary Main Substation (AMS) located within the premises of the Receiving Substation (RSS) performs the task of supplying 33 kV, 3-phase power supply to the 33 kV distribution network, through appropriate switchgear and protection arrangements. The AMS mainly comprises of:

- 220/33 kV Auxiliary Main Transformer,
- 33 kV AIS type switchgear including 33 kV Circuit Breakers, 33 kV busbars, 33 kV
- potential and current transformers as required, earth switches, protection relays, meters and all other components required for satisfactory operation of the switchgear. All Incoming & outgoing feeders shall be protected with Lightning Arrestors of suitable ratings. There shall be provision for testing of all Lightning arrestors / Surge arrestors provided in AMS system separately to ascertain proper working during service life.
- 33 kV / 415 V, 200 kVA Auxiliary dry type transformers
- 415 V AC Distribution Board
- Battery, Battery chargers cum DCDB

- Interface cubicle to act as a link between AMS equipment and 'GATEWAY' To SCADA
- Interconnecting power and control cables.

2.6.1 Auxiliary Main Transformer

i) Scope

These specifications are applicable to Auxiliary Main Transformer of 3-phase 220/132/66 kV Primary Voltage and 3-phase, 33 kV Secondary Voltage. Auxiliary Main Transformer shall be designed for outdoor installation and for operation at frequencies of 50 Hz.

The Auxiliary Main Transformer shall be complete with all Parts, Fittings, and oil for the first filling, and accessories necessary for its efficient operation, including mounting framework of steel. All such Parts, Fittings and Accessories shall be deemed to be within the scope of this Specification, whether specifically mentioned or not. The Auxiliary Main Transformer shall be of proven design.

ii) Governing Specification

The Auxiliary Main Transformers shall comply with the standards of the International Electro Technical Commission (IEC60076) or equivalent Indian standards.

iii) Standards

The Auxiliary Main Transformer shall satisfy the requirements given below and shall also comply with standards in force when they are manufactured, particularly which are in the following table (unless otherwise stipulated in the specifications, the latest version of the following standards shall be applicable): -

S. No.	Specification No.	Title of Specification
1	IEC-60076-1,2,3,4,5 & 7	Power Transformer
2	IEC-60214	Tap changer for power transformer
3	IEC-60296	Insulating oil for Transformer
4	IS-335	Insulating oil for Transformer
5	IEC-60028	Conductor for Insulated cable
6	IEC-60137	Insulating Bushing for rated Voltage above 1KV
7	IEC-617-2	Earthing terminal
8	IEC-60721-2-5	Specification for painting: - Environmental condition
9	ISO-12944-5	Protective Paint system
10	IEC-61099	Synthetic ester Oil (SEO) for Power Transformer
11	IS-16081	Synthetic ester Oil (SEO) for Power Transformer

iv) Characteristics

The Auxiliary power transformers shall meet the following characteristics:

- 3-phases type in mineral oil tank,
- Entirely submerged in mineral oil tank,
- Outdoor type, suitable for tropical conditions,
- On load tap changer on primary windings,
- Possibility of various load conditions
- Separate oil conservator
- Cooling by natural or forced air and radiators mounted on transformer,
- Both transformers in a Substation shall not work permanently in parallel (only during a transfer without breaking),
- Multiple Transformers shall be exactly similar and replacement for each other.
- Transformer plus ventilation system noise level should not exceed 70dB, at a distance of 1.5m
- The Vector group shall be: YN yn 0
- Should have thermo symphonic filter
- Oil expansion vessel with Air cell

v) Rated Power

The transformer shall be manufactured and guaranteed so as to provide a continuous power rating, measured across the secondary winding at a voltage of 33 kV under load.

Sl. No.	Name of RSS	Cooling System	Rating (MVA)
1			
2			

The nominal ratings thus defined shall result in temperature rises not exceeding those stipulated in the standards as specified below.

vi) Overload Capacity

The transformers shall be able to withstand an overload of 25% for duration of 2 hours, following continuous running at maximum continuous rated load without exceeding the limits of temperature rise stipulated in the standards as specified below.

In its bid, the supplier shall indicate the precise overload capacities of the equipment for 30 minutes, 1 hour, 2 hours and 4 hours rating, on the basis of the thermal balance resulting from extensive initial operation at load of 1/4, 2/4, 3/4 and 4/4 across the secondary winding.

After overload temperature remaining within the following limits: -

- 65°C above ambient temperature for oil.

- 75°C above ambient temperature for windings

vii) Rated Voltages

Primary Winding

The primary winding shall be star connected with neutral brought out and earth connected. The rated voltage shall be 220/132/66 kV at a power frequency of 50 Hz on the main tapping. Operating voltage may increase to + 10% and drop to - 15%. The insulation level of the Auxiliary Main Transformers shall correspond to the following values:

The primary winding shall be fitted with on-load tap changer on the neutral end, + 6 x 1.667%, - 9 x 1.667%. The primary neutral point of Auxiliary Main transformers should be earthed via a suitable capacity & rating of Current Transformer, isolator and surge arrester.

220/33 kV, 132/33 kV and 66 kV/33kV Transformers

Sl. No	Particulars	220 kV	132 kV	66 kV
1.	Primary winding rated Insulation voltage (system highest voltage) (in kV rms)	245	145	72.5
2.	Impulse withstand voltage for primary(in kV peak)	950	650	325
3.	Power frequency withstand voltage for primary (in kV rms)	395	275	140
4.	Primary Neutral connection rated insulation voltage (in kV rms)	145	72.5	52
5.	Impulse withstand voltage for primary neutral (in kV peak)	650	450	250
6.	Power frequency withstand voltage for primary neutral (in kV rms)	275	185	95
7.	Secondary winding rated insulation voltage (in kV)	36	36	36
8.	Impulse withstand voltage for Secondary winding (in kV)	170	170	170
9.	Power frequency withstand voltage for secondary winding (in kV)	70	70	70
10.	Maximum flux density (in Wb/m ²)	1.55	1.55	1.55

Secondary Winding

The secondary windings shall be star connected with neutral brought out and earth connected through NGR. The rated voltage shall be 33 kV rms as applicable.

The insulation level shall be of a 36 kV rms highest system voltage and the neutral end shall be fully insulated and earthed through a **19 Ω** resistor in order to limit the current to a maximum of 1000 A admissible into the 33 kV cable screen as applicable.

The secondary neutral point shall be earthed via a suitable capacity & rating of Isolator, Current transformers for earth protection and standby earth protection and surge arrester. The surge arrester shall be located as close as possible to this terminal. The calculations shall be submitted in the definition file of transformers at the time of vendor approval.

viii) On-Load Tap Changer

Voltage shall be substantially constant at the untapped windings (secondary windings) and variable at the tapped winding (primary winding). The category of regulation applied shall be constant-flux Variable Voltage regulation (CFVV).

The OLTC shall be fully type tested (type tests reports shall not be more than 05 years old at the **time of post bid vendor / make approval** or the type tests shall be conducted at no extra cost to employer). The on load- Tap changer shall be of suitable capacity, design and enclosure type, installed in a separated oil tank offering 16 steps (+ 6 step, normal and -9 step), each representing 1.667% of the nominal voltage.

It shall have the following characteristics:

- Enabling 50,000 operations without attention
- Motor and / hand-driven
- Manual, automatic, local remote control & monitoring OLTC from RSS control room and OCC
- Tap position indicators
- Commutation current compatible with the short duration transformer over-current.
- Diverter switches shall be designed for high-speed operation and shall be interlocked to ensure that there is no possibility of an operation stopping in mid-position. Arcing contacts shall be of tungsten alloy material.
- Positions disabled
- Devices to ease extraction for maintenance purpose.
- Automatic / Manual and Local /Remote selector switch operation, Control & Monitor of OLTC from RSS control room and OCC
- OLTC shall Block operation in case any of the pole gets stuck.
- Auto operation of the OLTC shall be block in case of transformer CB is in open condition.

The oil volume of the on-load tap changer unit must be separated from the tank for core and winding oil.

The power circuit of the on-load tap changers shall be connected to the neutral of the primary windings and shall enable the voltage variations.

The full technical description shall be given as regards power and auxiliary circuits; periodicity for checking and overhauling the power circuit shall be indicated in the transformer maintenance Manual. The servomechanism settings shall be designed and executed to avoid too many actuations

As the transformer is deemed to run in parallel during power transfer, OLTC shall be fitted with a servo-mechanism suitable for such a purpose. The manufacturer shall provide mechanical and electrical diagrams. A suitable protection relay shall be connected on the oil pipe between the on-load tap changer and the expansion vessel.

The voltage ratio shall be checked according to the guaranteed figures and the tolerances stipulated in the standards.

Cooling System

The power transformer shall be designed to operate in ONAN/ONAF mode (mineral/ester synthetic oil natural / air natural/air forced) The oil along with inhibitor to be used for the transformer must be in conformity with the IEC 60296 / IS 12463 standards, and of the highest non-inflammability degree. The maximum temperature allowable at nominal rating for each cooling condition (natural and forced air) shall never exceed:

- 50°C above ambient temperature for mineral oil
- 55°C above ambient temperature for the copper winding and the iron core.

Oil breakdown strength during test should be more than 55kV/2.5 mm. The transformer will be rejected in case the temperature rise exceeds the guaranteed values by more than five degrees centigrade.

The transformer oil shall comply with the requirements of RDSO viz. IS 12463:1988 with following additional requirements:

Oxidation stability:

- Neutralization value after oxidation -0.2mg KOH/g (max)
- Total sludge after oxidation -0.05% by mass(max)
- Presence of oxidation inhibited -0.25 to 0.30% by mass

The PST contractor shall give full description of the design, operation and maintenance of the proposed air-cooling system and indicate the air flows needed for ventilating the cubicle and the air-cooling units: -

- For Natural Ventilation
- For Group-I assisted Ventilation
- For Group-II assisted Ventilation.

In case of fire detection into the transformer cubicle, the air-cooling system shall be immediately and automatically switched off.

Short-Circuit Withstand

symmetrical current to an allowable value, the impedance voltage shall never be less than twelve percent (12%). At rated power and frequency on the main tapping, the impedance voltage shall be equal to about twelve-point five percent (12.5%) inclusive of tolerance as The transformer shall be designed and constructed so as to withstand without damage, whatever may result, from an external short-circuit. The primary winding of the transformer shall be designed for carrying the full symmetrical short circuit current, for 3 sec. The full symmetrical short circuit current shall be calculated in accordance with IEC after taking into account the system impedance on the primary voltage of the transformer.

The design of the primary side bushings of the Transformers shall withstand the symmetrical current for three seconds during short-circuit on primary voltage, as specified in IEC 60076-5.

To limit the short-circuit per IEC 60076-1.

x) Iron Core

The magnetic core, frame assembly, clamping and general structure of the transformer shall be mechanically sturdy so as to be capable of withstanding shocks which may happen during transport or during short-circuit and over-voltage times.

Cores and magnetic circuit shall consist of cold-rolled grain-oriented silicon steel sheets. They shall offer guarantee of durability in time, heat resistance and oil resistance. The tightening bolts shall be suitably insulated, and the ground of the magnetic circuit shall employ generously sized copper connections and links.

The keying and compression of the laminations, together with the induction value, shall be designed so as to keep vibrations to a minimum and to reduce, in particular, the third and fifth harmonics influences. Calculation sheets to establish maximum flux density (i.e. 1.55 Tesla) shall also be submitted with Design to employer. The PST contractor shall submit complete technical data of the system to the employer. During testing, noise shall be measured according to the standard and the guaranteed minimum noise level shall be as low as possible for transformer of this power.

xii) Transformer Losses

The transformers shall be designed for minimum losses. When comparing between different tenders the present value of the capitalized cost of losses in the transformers shall be added to their financial bid by the following formula

$$PW = K * 365 * 24 * C (W_{ir} + b^2 W_{cu}) / 1000$$

Where

- PW is the present worth (in IR) of annual capitalized cost of losses at 8% rate of interest over 25 years
- K is the present worth factor (8% interest, 25 years) = $\{(1+0.08)^{25} - 1\} / \{0.08 * (1+0.08)^{25}\} = 10.675$
- C is the cost of the kWh (in Indian Rupees) = **Rs. 6.60**
- W_{ir} is the iron losses in Watts at normal voltage and main tapping
- W_{cu} is the full load copper losses in Watts at normal voltage and main tapping at 95°C
- b is the load factor of transformer = 50 %

$$\text{Thus } PW = 10.675 * 365 * 24 * 6.70 (W_{ir} + b^2 W_{cu}) / 1000$$

$$PW = 617.8 (W_{ir} + 0.25 * W_{cu})$$

In case the transformer losses during tests are found greater than the values guaranteed in the offer, a consolidated penalty shall be paid by the PST contractor, according to the following formula (for the tolerance permissible according to IEC standard):

$$617.18 (d * W_{ir} + 0.25 * d * W_{cu})$$

Where, W_{ir} and $d W_{cu}$ are the differences between the test values of iron losses at full

voltage and copper losses at full load on one transformer at main tapping and the values guaranteed in the offer.

Windings

The winding conductors shall be made of best quality high conductivity electrolytic copper, in compliance with the standard (IEC 60028) requirements. Both windings, primary and secondary, shall be designed to withstand over-voltage and over-current in case of direct short-circuit across the medium voltage terminals with the primary winding line for three seconds.

The adjustment windings shall be designed specifically to withstand direct short-circuit of all part of the adjustment turns that may occur at the contact plates of the on-load tap changer switches. The winding, connections and terminal links shall be properly brazed so as to withstand the shocks and vibrations which may occur during transport or short-circuit time. Testing of samples must be carried out and submitted for approval during in-plant inspection before starting assembly of the transformer windings.

Current density for each winding should be not more than 2.5 A/mm². The insulation material used for the transformer windings and connections shall be of class A. Calculations for selecting the insulation class shall be submitted for approval, however, in no case the insulation class shall be lower than class A.

xiv) Terminals and Connections

The primary and secondary connections shall be realized through porcelain/polymeric bushings insulators as applicable. The porcelain shall be brown glazed. It shall be unaffected by atmospheric conditions like fumes, ozone acids, alkaline, dust, sand storms or rapid change in temperature between 0°C and 75°C under working conditions and the prevailing environmental conditions/changes in Bengaluru.

In order to avoid damages to tank in case of disruptive discharge, bushing base should be connected to the earth. Creepage distance for one bushing should be 31 mm/kV. Bushings shall be realized in conformity with the IEC 137 standard. Special care shall be taken against transmission of vibrations by employing a damping system and suitable fittings.

The design shall take into account the ease of overhaul. It should be possible to withdraw and to remove the transformer at ease. Interchangeability between transformers shall be achieved through the use of identical elements. The link between secondary terminals of the transformer and the switchgear shall be made by cables connected directly at the outside of the secondary bushing. Bushings shall be realized in conformity with the IEC 137 standard. The bushings shall be fully type tested within last 05 years as per relevant IEC at the time of approval or the type tests shall be conducted at no extra cost to employer. Calculations for wind load, cantilever load etc. shall be submitted at the time of vendor approval

xv) Tank

The transformer tank shall be made of high-quality boilerplate steel as per IS2002 with stiffening frame and girders. The width of the welding sections shall be sized so as to permit three dismantling operations by grinding before having to completely reform them. The thickness of the tank should not be less than 10 mm. and the tank should withstand full vacuum. The PST contractor shall provide all necessary guides for mounting and removing of the tank.

Tank shall be connected to the earth at two different points. In case of separated radiators, they shall be earthed and consequently pipes network shall be mounted with insulating joints.

The tank, valves, joints and gaskets shall be air-tight, water-tight and oil-tight. The junction shall be capable of withstanding the temperature of a fire without causing any major leak as per IEC 60076 standards. For this purpose, the flanges connecting the tank to the pipework and the flanges between parts of the pipework shall be designed with particular care.

The tank shall be reinforced in order to render it capable of withstanding the pressure caused by the various mineral oil treatments. The tank shall be fitted with hooking points to enable it being lifted in balance by means of an overhead travelling crane, as the main package on a road trailer or in form of the complete unit, fully equipped and filled with mineral oil.

The tank shall be secured to a frame equipped with bi-directional and removable rollers made of cast iron and fitted with locking devices. The frame shall enable the transformer being laid normally on a slab or foundation block, without rollers.

The tank shall be equipped with the following auxiliary devices:

- > manholes on the tank cover, if necessary,
- > flanged oil drainage valves,
- oil sampling cocks at top and bottom of the tank,
- flanged valves suitable to connect the oil filtering unit,
- special pockets for checking by thermometers,
- earthing terminals and also provision of CFT (Core, Frame & Tank) terminal.

Transformers shall be fitted with over-pressure relief device provided with electrical contacts. Name plate to be provided with all technical particulars

xvi) Oil Expansion Vessel

The transformer shall be equipped with an oil expansion air-cell vessel placed above the transformer. The oil expansion vessel shall be partitioned so as to avoid mixing between the on-load tap changer oil and the core and winding oil.

It shall be connected to the transformer through all the necessary pipe-works, fitted with flexible metal joints and gaskets; the connecting pipe shall over-extend vertically inside the vessel (at least 8 cm)

The various drainage valves, oil sampling devices and relief valve shall be provided and easy to reach for each partitioned volume. The Self dehydrating breather with Silica gel or equivalent fitting and checking glass shall be accessible easily to change the dehydrating product during operation of the transformer.

The oil level indicator with auxiliary contacts shall be easily observable from ground level.

The oil volume should not reach:

- the minimum level by 0°C (Ambient temp.)
- the maximum level by 50°C (Ambient temp.)

xvii) Control and Protection

The transformer shall be delivered with "Buchholz", thermal and earth fault protections, all connected to the control and monitoring cabinet.

Buchholz: The term "Buchholz" protection denotes the gas-sampling device and relay for gas fault detection and storage for analysis. The relay shall comprise two thresholds as follow:

- alarm in case of minor fault such as local overheating of windings or core (small gas discharge),

- tripping-out in case of major fault (violent gas discharge) or important oil leakage.

Both transformer and on load-tap changer oil circuits shall be equipped with "Buchholz" protection. They shall be connected to the oil pipe between the tank and the expansion vessel, without any flat part and any less than 50mm band.

It shall be free for access and maintenance; a by-pass system shall be provided to enable oil flow without interrupting operation during maintenance checks. In order to ease gases chemical analysis, the gas-sampling device shall be accessible during transformer operation, at man level.

Thermostat: The thermostat itself shall be installed in the monitoring box, while the indicator on its facade and the thermal probe shall be installed into the tank with appropriate pocket.

xviii) Control and Monitoring Cabinets

Made of stainless steel-sheets, grade- AIS-316(2 % Mb) totally enclosed, dust-proof and waterproof type (IP55) suitable for outdoor applications it shall be equipped with:

a) For transformer

- Access doors with padlocks
- 415 /240 V protection and power circuits.
- 110 V DC control and monitoring relays
- Internal lighting monitored by the door position.
- Heating thermostat with indicators and contacts
- Information terminal block
- Remote control and monitoring multi-pin connector
- Cooler Control system as per following modes
- Auto/Manual
- Local Remote
- Fan Control

b) For On-load tap changer

- Access doors with padlocks
- 415/240 V protection and power circuits.
- 110 V DC or 415 V AC (3ph) / 220 V AC (1ph) control and monitoring relays
- Internal lighting monitored by the door position.
- On-load tap changer operating equipment and control
- Counter
- Information terminal block
- Remote control and monitoring multi-pin connector
- OLTC tap position should operate based on voltage level of primary side voltage of Transformer. This provision shall be provided with PLC based logic and PLC should be

installed in the RTCC indoor Panel and should have adjustable time & dead band on voltage settings for OLTC tap operation feature.

- Alternatively, Diverter switch with multi ratio PT arrangement may be used for OLTC operation on primary voltage sensing.
- RTCC panel should have TPI (tap position indicator) & Remote, Auto and Manual Operation of OLTC.
- Control of Auto / Manual and Local/Remote selector switch shall also be possible from OCC /Local SCADA.
- Trip indication of Fan to be provided

All control and monitoring cabinets used in indoor shall conform to the following minimum specifications

Material		Steel
Minimum thickness of Steel sheets	:	3mm for front cover & base frame 2 mm for rear door 1.6 mm for roof plate, bottom plate & side covers
Powder Coating :		
Exterior	:	RAL 7032, Texture finish
Interior	:	RAL 7032, Texture finish
Base frame	:	Black
Thickness		Min. 80 microns of Powder coating

The PST contractor shall submit to the Employer, the complete details of the Control & Monitoring Cabinets, including details of the structure, process of finish and painting, wiring, terminal blocks, cubicle illumination heating etc., for Employer's approval.

The details adopted for Control and Relay panels, Bay Control and Protection units, Transformer and On-load tap changer cubicles and all other Control and Monitoring Cabinets, located inside the RSS Control Room shall be identical to project an aesthetically good appearance

xix) Metal Work and Paintwork

Painting should be suitable for salty seaside atmosphere and has to comply with IEC 60721-2-5 standard. The entire surface (Internal as well as External) to be painted shall be prepared by Shot blasting to cleanliness level, SA21/2 as per ISO 8501/SIS 055900. Ensure that the cleaned surface is free of oil or grease, scales rust and other residue. Surface profile of the blasted surface should be approximately 40-60 microns.

All the external surface of the transformer shall be given first coat of Epoxy zinc rich (having minimum 83% metallic zinc) primer (Min.50 microns thickness), first intermediate coat of epoxy zinc phosphate paint (Min.60 microns thickness), intermediate coat of Epoxy high build MIO (Min.80 microns thickness), and final coat of glossy Aliphatic Acrylic polyurethane (Min.50 microns thickness).

The total dry film thickness (DFT) of the paints shall be minimum 240 microns and should withstand 120°C. The shade of paint shall be gray shade 631 as per IS: 5.

All steel surfaces which are in contact with insulating oil shall be painted with heat resistant oil- insoluble insulating varnish. After baring, all metal surfaces shall receive anti-corrosion process (as per IEC 60721-2-5 standard):

- Natural stainless for Bolts & screws
- Hot dip galvanization for radiators
- Rust-proofing and anti-corrosion paint for tank, oil expansion vessel and other

metal surfacesThe transformer and its accessories shall be completely painted in plant. The necessary touch-ups shall be executed on-site after erection. This protection shall be fully guaranteed for five years starting from provisional taking over. Should any noticeable deterioration by rust or corrosion appear before this time elapses, the PST contractor should be responsible for repainting at his own expense and for renewing his guarantee for the work performed.

The painting and preserving of panels for transformer protection should be similar match with that of other control and relay panels provided in the control room.

xx) Particular Dispositions, Installation

Transport

For transport either by road, ship or rail, the transformer shall be filled with oil up to windings top and then with Nitrogen at recommended pressure up to the tank top or alternatively, the transformer may be filled with Nitrogen, in full, during transportation. The Impact Recorder shall be mounted on every power transformer (on returnable basis). The result of the impact recorder shall be shared by the PST contractor with BSTP.

The bushing, breather, wheels and all other external parts shall be removed on condition that they can be mounted at site.

Installation

The transformers are to be installed at the RSS-cum-AMS on two running rails, and consequently must be delivered with a set of swiveling rollers. These rollers shall be mounted electrically insulated from tank and with locking devices. The Insulation Resistance (IR) values shall be measured of Power Transformer before unloading and after placements on running rails. IR values between core clamps and core laminations, core to earth and clamp to earth shall be particularly required.

Material layout and volume shall permit an easy access to every part of the equipment, in particular those requiring maintenance. The PST contractor shall indicate the method of handling all the parts from the main access of the RSS.

xxi) Grounding of Power Transformer Neutrals**Primary Voltage Neutral**

The high voltage neutral shall be solidly earthed through an isolator whose open or closed position shall be according to the general operating condition of the distribution network. Switches shall be of single phase, air insulated and manually controlled.

Their insulation level shall be suitable as per primary voltage of transformer. The actuation level shall be at man height level. Locks and keys shall be provided to achieve the safety interlocking conditions. Flexible braids to a copper bar insulated shall connect the primary neutral terminal and whose cross-section shall enable the current flowing to earth in case of failure. This link shall be fitted with oil type current transformer and a surge arrester, situated as close as possible to the neutral terminal.

The neutral earthing support structure should be protected on all sides by GI mesh supported suitably on GI support structures. If earthing is done by suitable insulation level cable then fencing is not required.

Secondary Voltage Neutral

Grounding of each neutral of the secondary windings of the power transformers shall be made through a resistor and an Isolator. Temperature rise according to the duty class shall be reduced to the minimum possible and never exceed the values stipulated by the IEC standards.

Neutral Grounding resistor (NGR) shall be installed next to the transformer and shall be surrounded by a frame to avoid any access when the transformer is working. The frame door shall be interlocked according to this condition.

The NGR body shall be stainless steel (SS-304) painted with three coats of nonmetallic paint of the same quality, description and method as that used for outdoor transformers, total thickness should not be less than 240 µm and should withstand 120 °C.

The PST contractor shall be responsible for the following, for each of these resistors:

- Installation and securing,
- Connection from the resistor input terminal to the neutral terminal of the
- Transformer via suitable size of a copper cable with suitable insulation fixed on wood clamping blocks and with a cross-section suited to the operating rating of the resistor.
- Setting and erection of a single-phase, manually controlled, air insulated, isolator
- Provided to isolate the resistor from the transformer side
- Connection from the resistor output terminal to the underground earthing circuit
- of the station via copper bus-bar.
- Erection and connection of various current transformers
- Installation and connection of a current transformer after the output terminal of
- the resistor.

- Grounding of the various main metal sections
- Surge arrester situated as close as possible to the transformer neutral terminal.

The isolator shall be of single phase, air-insulated and manually controlled. Isolators, surge arresters and current transformers shall be installed on a portal located respectively over the neutral resistors. Thermostat and space heater shall also be provided

xxii) Fire Protection and Suppression System

In terms of CEA (safety regulations), 2010 "transformers of 10 MVA and above rating or in case of oil filled transformers with oil-capacity of more than 2000 liters are provided with firefighting system as per IS - 3034: 1993 or with Nitrogen Injection Fire Protection system. In view of above, transformer shall be provided with "Nitrogen Injection Fire Protection System". The specifications of "Nitrogen Fire Protection System" are detailed as below: -

Nitrogen injection fire protection system designed for oil filled transformers shall prevent tank explosion and the fire during internal faults resulting in an arc, where tank explosion will normally take few seconds after arc generation and also extinguish the external oil, fires on transformer top cover due to tank explosion and/or external failures like, bushing fires, OLTC fires and fire from surrounding equipment.

The system shall work on the principle of DRAIN AND STIR and on activation: it shall drain a pre- determined quantity of oil from the tank top through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and reduce the temperature of top oil surface below flash point to extinguish the fire.

Conservator tank oil shall be isolated during bushing bursting, tank explosion and oil fire to prevent aggravation of fire.

Transformer isolation shall be an essential pre-condition for activating the system. The system shall be designed to operate automatically. However, it shall be designed for manual operation, in case of failure of power supply.

The system shall consist of following equipment:

- Fire extinguishing cubicle placed on a plinth at about 5-10 meter away from the
- Transformer.
- Control box placed in the control room.
- Pre- stressed non return valve in the conservator pipe.
- Required number of fire detectors on the tank top cover.
- Signal box fitted on the tank top or tank side wall

A. Scope

The scope of this specification covers design verification, supply, testing at works before dispatch, erection, testing and commissioning and performance demonstration of "fire protection and extinguishing system by "Nitrogen injection method". The necessary civil work which will be required for construction of oil soak - pit for the storage of oil coming out from the transformer and plinth for extinguishing cubicle is in the scope of the PST contractor , laying of oil pipe, nitrogen pipe, electrical cables, control boxes, extinguishing cubicle, nitrogen cylinder, PRY, fire detectors and other equipment & accessories required for erection, testing, commissioning and performance demonstration of the complete fire protection system is in the scope of the PST contractor . It will be the responsibility of the PST contractor to ensure coordination transformer manufacturer and the supplier of the Fire Protection System for all the arrangements for the complete erection, testing, commissioning and performance tests.

Notwithstanding the technical specifications and requirements mentioned herewith any modification can be incorporated for correct operation of nitrogen injection fire protection system without extra cost. The full details of the same are required to be submitted to BSTP for approval.

B. Operational Controls

The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control remote electrical push button control on control box and local manual control in the fire extinguishing cubicle shall be provided. Spare interlocks are to be provided for ensuring that it should not be possible to close HV or LV circuit breakers to energize the transformer after the activation of the fire prevention and, fire extinction system.

C. System Activating Signals

Transformer isolation shall be an essential pre-condition for activating the system. Transformer isolation through Master trip relay or circuit breaker (HV and LV side in series) has to be incorporated. Besides, two electrical signals to be provided in series, for activating the system as under:

For Prevention:

- Differential relay,
- Buchholz relay paralleled with pressure relief valve

For Extinction:

- Fire detector.
- Buchholz relay paralleled with pressure relief valve

D. System Equipment

- a) Fire Extinguishing Cubicles (FEC), placed on plinth at about minimum 5 meter away from the transformer shall consist of:

- Nitrogen Gas cylinder with regulator and failing pressure electrical contact

- manometer.
 - Oil drainpipe with mechanical quick drain valve.
 - Electromechanical control equipment for oil drain and pre-determined regulated nitrogen release.
 - Pressure monitoring switch for backup protection for nitrogen release.
 - Limit switches for monitoring of the system.
 - Flanges on top panel for connecting oil drain and nitrogen injection pipes for
 - transformer.
 - Panel lighting
 - Oil drainpipe extension of suitable sizes for connecting pipes to oil pit.
- b) Control box with activating, monitoring devices and line faults indicators. (To be placed in control room). It should have audio visual alarm indication and push button switches.
 - c) Pre-stressed Non-Return Valve (PNRV) to be fitted in the conservator pipe line, between conservator and Buchholz relay operating mechanically on transformer oil flow rate with electrical signals for monitoring.
 - d) Fire detectors to be fixed on transformer tank up cover and On Load tap Changer for sensing fire.
 - e) Signal box to be fixed on transformer side wall for terminating cable connections from fire detectors and PNRV
 - f) All other consumables necessary for complete system.

E. Other Requirements for System Installations

- a) Oil drain and Nitrogen openings with gate valves on transformer tank at suitable locations.
- b) Flanges with dummy pipes in conservator pipe between Buchholz relay and conservator tank for fixing PNRV.
- c) Fire detector brackets on transformer top cover.
- d) Spare potential free contacts for system activating signals i.e. differential relay, buchholz relay, pressure relief valve, transformer isolation (master trip relay).
- e) Status of Fire Protection System Operated, NIFPS out of service, PNRV/TCIV valve close, Fire detector initiation alarm/trip, and Nitrogen cylinder pressure low, Visual/Audio Alarm for NIFPS system and Visual/Audio Alarm of NIFPS for DC supply fail shall be available on the Local/OCC SCADA.
- f) Pipe connections between transformer to fire extinguishing cubicles and fire extinguishing cubicle to oil pit.

- g) Cabling on transformer top cover all fire detector to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle.

h) Plinth for fire extinguishing cubicle. Oil pit with suitable capacity.

F. Technical Details

Fire extinction period

- | | | | |
|---|---|--------------------|----|
| > On commencement of Nitrogen injection | : | Maximum | 30 |
| seconds | | | |
| > On system activation up-to post cooling | : | Maximum | 3 |
| minutes | | | |
| > Fire detectors heat sensing temperature | : | 141 deg celcius | |
| > Heat sensing areas | : | 800 mm radius | |
| > Pre-stressed non-return valve setting for operation | : | Minimum 60 ltr per | |
| minute | | | |
| > Power Source: | | | |
| . Control Box: | | 110 V DC | |
| . Firefighting cubicles for lighting: | | 240 V AC | |

G. Cabling:

Fire survival cables, able to withstand 750°C, 4Cx1.5 mm² for connection of fire detector in parallel shall be used. The test certificates for the cables shall be submitted.

Fire retardant low smoke (FRLS) cable 12C ×1.5 mm² for connection between transformer signal box/marshalling kiosks box to control box and control box to fire extinguishing cubicle shall be used.

Fire retardant low smoke (FRLS) cable 4Cx1.5 mm² for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal box/marshalling box to pre-stressed non return valve connection on transformer shall be used.

H. Previous Experience for Qualifying Supplier:

The supplier shall have a minimum experience of two years in the design, manufacturing, erection, testing and commissioning of nitrogen injection fire protection system on power transformers of similar or higher rating. At least 2 sets of the system shall be in successful operation for a minimum period of the 2 years. The supplier shall furnish the details of nitrogen injection fire protection system supplied by them so far, giving order reference, name and address of the customer, indicating the dates of commissioning as well as performance certificate of successful and satisfactory operation for minimum two years from the customers.

I. Tests

Type

Test

Type Test reports including that for detectors along with declared response time shall be submitted within the tender. The system shall be tested by reputed international testing body or a national testing body (BIS) recognized laboratory). TAC approval, if any, shall be submitted with the tender.

Factory Test

Tests will be carried out on individual equipment of the system and the total system in the supplier's workshop in presence of purchaser's representatives.

Performance Test

Performance test of the complete system shall be carried out after complete erection at site by the supplier's representatives. These tests shall include simulation and verification of the response of the complete system without actual draining of the oil and injection of the nitrogen gas.

In addition to above, additional tests as required necessary shall be conducted.

J. Drawings and Manuals

Detailed layout drawings along with the equipment drawing to be given in the proposal along with the complete bill of materials. After awarding of contract, detailed dimensional drawing of the system complete bill of materials including location and size of plinth for cubicles and recommended capacity of oil soak-pit shall be submitted for purchaser's approval. After approval 4 (four) sets of all above drawings and 4 (sets) sets of operation and maintenance instruction manual (bound) shall be submitted for purchaser's use.

K. Spares

One full set of spares nitrogen gas filled cylinder, 50 % of the installed no. of fire detectors (heat sensing element) shall be provided in addition to additional other recommended spares. The list of recommended spares is to be submitted along with the proposal of vendor approval.

A. Test Sheet and GTP

All type tests and routine tests of Transformer, ON load tap Changer and Bushings as per relevant IEC standards specified in technical specifications shall be carried out. Short circuit withstand test shall be conducted on one each type and rating of transformer to validate the design and quality unless such test has been conducted within last five years on the transformer of same design. In case there is change in design before five years, the new transformer design shall be validated by carrying out short circuit withstand test. All the type test report shall be valid at the time of vendor approval.

The PST contractor shall submit fully filled technical data sheet given in chapter 8B of PS along with other relevant data during technical approval.

xxiii) Ester Oil Filled Transformers

If the employer requires ester oil filled transformer, the PST contractor shall submit detailed design of the transformer along with relevant extracts of applicable International/Indian

standards. Any savings in size due to ester oil shall be clearly specified. The PST contractor shall submit the credentials to assist proven- ness of the design. Transformer shall be designed with thermally upgraded papers and OLTC other accessories shall be designed with high temperature rises, so as to minimize the size of the transformers. The adjustment price of transformer with synthetic ester oil is to be quoted in pricing/BOQ document.

2.6.2 33 kV AIS Switchgear

33KV Switchgear for AMS will be SF6/Vacuum type.

This 33kV equipment shall include one Auxiliary 33kV cable bridge metal-clad type cubicles

This bridge shall be divided into two half bridges, each one comprising of the following:

- 1 Auxiliary Bridge Circuit Breaker (LBCB) cubicle,
- 1 Auxiliary 33 kV cable Circuit Breaker (RCCB) cubicles
- 1 Low voltage Auxiliary Transformer Circuit Breaker (LVATCB) cubicle
- 1 spare circuit-breaker (LFCB) cubicles.
- 1 Spare Circuit-breaker for Reactive power compensation device
- Auxiliary circuit breaker for RSS located in/near depot.

All 33 kV circuit breaker shall be provided with one set of 3 phase 33 kV voltage transformer on cable side and Suitable capacity & type of Surge Arrester shall be installed Phase to Ground Earthed properly.

These two half bridges shall be linked through

- 1 Coupling Circuit Breaker (LBCCB) cubicle
- 1 bus riser cubicle if required

A circuit breaker complying with all necessary safety conditions and interlocks shall be capable of being mounted inside each circuit-breaker cubicle.

2.6.3.1 Switch gear cubicles

2.6.3.2 General data

All circuit breaker cubicles shall be of the same type. All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers. All panels, separating partitions and accessories shall be mounted similarly,

in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit-breakers and their actuation.

2.6.3.3 Electrical characteristics

The service voltage is 33 kV. The insulation level is 36 kV minimum Compliant to latest IEC. All parts of the cubicle (bus-bars, sliding connector, partition passages) shall be capable of permanently withstanding the temperature rise caused by the currents and shall match the nominal rating of the circuit-breaker provided.

The cubicles shall be capable of withstanding without any damage the loads generated by 1500 MVA peak short-circuits. The number and frequency of those are not limited in time.

2.6.3.4 Cubicles common part

It must be of metal-clad switchgear type, closed by a door forming the facade, equipped with riveted marking plates and single-wire diagram also fitted with the display lamps indicating the presence of 33 kV voltage.

2.6.3.5 Make-up / construction feature

Each cubicle will be metal clad type, air insulated, made of:

- Bar set compartment
- Cable end compartment
- Low voltage (measure, protection & monitoring) compartment
- Apparatus connector compartment with shutter
- Withdrawal trolleys

Metal clad envelope with appropriate hanging devices

Compartments will be physically separated from each other by metal partitions, which shall not heat up due to induced magnetic fields action.

All panels, separating partitions and accessories shall be mounted similarly, in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit-breakers and their actuation

All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers.

Internal and external metal partitions are connected to the earth, high voltage electrical links are realized with bushing Auxiliary voltage shall be 110 Vdc +10, -20 % for motors, monitoring and control circuits, Note that all parts of the cubicle (bus-bars, sliding connector, partition passages) shall be capable of permanently withstanding the temperature rise caused by the currents and shall match the nominal rating of the apparatus.

All Panels shall be Internal Arc tested for full fault current as per AFLR for 1 second.

The cubicles shall be protected against fire by means of an 'automatic fire detector and extinguisher system', 'Fire trace' type or equivalent, complete as per detailed specification given

in Annexure-5. The PST contractor shall submit the complete technical data of the system to the Employer, for approval.

2.6.3.6 Equipment

Cubicles will mainly be equipped with:

2.6.3.6.1 Trolley receptacle compartment:

- Fixed earthing plug-in contact
- A shutter automatically protecting live pieces when the apparatus is plugged-out
- Grounding of the frame of the trolley
- A safety interlocking access to the fixed insertion connectors if the circuit-
- Breaker is not in the cubicle or if it is in the withdraw position.
- A precise device for displaying the end of insertion travel with limit switch- a fixed plug-in socket enabling the flexible connection to be made for control

- And monitoring of the circuit-breaker
- The interlocking corresponding to the function of the cubicle
- A general connecting terminal for low voltage circuits of the cubicle. The terminals shall be tightened by screws; no other connecting device shall be used
- An annunciation device for 33 kV voltage on, by mean of a capacitive divider with neon lamps (one per phase), glowing permanently in live conditions.

2.6.3.6.2 Bar set compartment:

- 33 kV, 2000A bar set mounted on insulators, suited to withstand 1500 MVA peak short-circuit.
- Inter-cubicles high-voltage connectors.

In principle, the bus bar shall be of copper and shall be a rectangular cross-section. Alternatively, hollow tubular busbars are acceptable, provided they meet the current requirement of 2000A.

2.6.3.6.3 Cable end compartment:

- One or two sets of three current transformers for protection and measurement.
- Three display lamps for voltage on fed by capacitive dividers, annunciation lamps being installed on the front face of the cubicle.
- End-boxes for 33kV three-phase cables of dry type aluminum or copper of appropriate cross-section, this box shall be supplied complete with all the necessary materials for installing the cable and completely making the end connection.
- The connection braids between the two sets of bus bar, the current transformers and the cable end-box., with sufficient gap so that when the braids are removed, the output terminals from the cable box be sufficiently distant from any earth, thus enabling the high voltage cable to undergo dielectric tests or any fault finding to be carried out by applying high voltage.
- A cable head earthing isolator with full making capacity, actuated manually, complete with the necessary interlock. Positions of the earthing isolator shall be visible through a glazed port.
- Voltage transformers.
- Surge arresters as per IEC 61850 protocol & Earthed properly.

This compartment height shall be at least 800mm to ease cable connection and be equipped with an external cable support device. All CB panels shall have integral earth switch with full making capacity for cable side earthing.

2.6.3.6.4 Low voltage compartment:

- Voltage presence capacitor dividers, relay, Master Trip Relay (MTR) with reset through SCADA and facade indicator light.
- Open/closed and connect/disconnect position indicator lights and contacts.
- Digital type Facade measurement indicators (counter, Ammeter & Voltmeter when

required)

- Control and monitoring devices for the CB (programmable logic control)
- Control and monitoring, multi pin connector.
- Lockable access door
- Local /remote switch.
- TNC switch for local operation in which close function shall active in local mode and inactive in remote mode. Trip function remains active in all modes.

2.6.3.6.5 Withdrawal Trolley:

- Self-contained trolley fitted with rollers allowing 3 positions:
- Plugged-in
- Plugged-out (test position)
- Out of the cubicle
- The Apparatus (see « Circuit breaker » herein below)
- an apron panel of sheeting, on the front face, carrying the control button and the open and closed position annunciation via mechanical display,
- A low voltage connector for all the control and annunciation (flexible multiple in connectors to the corresponding receptacle on the cubicle) with a device for securing the plug when handling the circuit-breaker,
- A grounding contact connecting the frame circuit of the circuit-breaker to the cubicle grounding busbar,
- All the interlocking mechanisms,
- A plugging actuator, if necessary,
- A manual actuating auxiliary system, provided with an interlocking device to avoid electrical control in this case,
- Auxiliary annunciation contacts displaying whether the circuit-breaker is in open or closed position, connected to the terminal board of the low voltage circuits.
- An operating counter.
- Spare open and closed contacts shall be available in addition to those used for low voltage control and monitoring circuits.

The actuating system shall be of energy accumulation type, with low transient current consumption when arming the circuit breaker. It shall be equipped with an anti-hunting device. Rack in/rack out of withdrawal trolley shall be smooth and easy without any removable tray.

2.6.3.6.6 Cubicles arrangement

All cubicles, boxes or sheaths must be rigidly fastened to the floor. Cubicle level adjustment can be realized with special steel sections initially anchored in position. The assembly level thus executed shall enable smooth pulling of the trolleys in the cubicles.

2.6.3.6.7 Cubicles grounding

Each cubicle shall comprise a Copper/ GI grounding bus-bar of suitable cross-section to which each of the metal masses of the component parts of the cubicle shall be connected, together with those of the instrument transformers.

The grounding bus-bars of the various cubicles shall form a linkage interconnected together and a common single collector line shall be provided for connecting it to the earthing circuit of the station.

The withdrawal trolley will be connected to this grounding bus-bar via a plug-in/out contact. The cable end manual earthing isolator position shall be visible, through a glazed port.

2.6.3.6.8 Paint-work

Painting should be suitable for polluted atmosphere and has to comply with IEC 607212-5 standard

After baring of all metal surfaces, an initial coat of rust-proofing and anti-corrosion paint will be applied; then they will be covered with two coats of paint and one finishing coat, colour to be defined.

2.6.3.6.9 Protection level

Cubicle enclosures and medium voltage sheaths shall provide an ingress protection level, IP -3X minimum.

2.6.3.6.10 Identification

The front of each cubicle shall carry a nameplate indicating its identification number and function. The text and type of nameplate shall be defined later.

2.6.3.7 Apparatuses

2.6.3.8 Circuit breakers

2.6.3.8.1 Make-up & equipment

Each Circuit Breaker will be three pole type and Vacuum/SF6 type and will include:

- Up & down stream plug-in connectors
- Life insulated poles
- Energy accumulation type actuation system (electromechanical springs)
- Electric and manual arming capability (Tripping and closing coils motor...)
- Under-voltage tripping coil (Auxiliary voltage off)
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable

2.6.3.8.2 Self-Interlock requirements

Circuit-breaker can be plugged-in or out only if tripped-out. All access to the fixed plug-in parts is prevented when the circuit breaker is withdrawn. The interlock shall fulfill the following conditions:

- When unplugged and withdrawn from the cubicle, the circuit breaker shall inhibit opening of the flaps covering the receptacles and shall enable the key to be turned. By turning the lock and withdrawing the key, it shall not be possible to plug-in the circuit breaker.
- In addition, for the outgoing 33 kV cable cubicles, it shall be possible to actuate the earth isolator only after first unplugging the circuit breaker and withdrawing the first key.
- Conversely, the earth isolator being closed, it shall not be possible to unlock the cubicle in order to plug a circuit breaker in.
- The type of lock shall be selected among equipment considered as being safety equipment.
- A general diagram of the key interlocks for the station, indicating all the locks provided for the present equipment shall be prepared.
- Mechanical interlock to be provided to prevent movement of breaker from service to isolated position OR vice versa in closed position and if attempted, shall open the breaker.

NOTE: It shall invariably be possible to padlock the interlocks

2.6.3.9 Current transformers

Each Current transformer will be installed in the cable end compartment between the downstream pole and the cable connector and at least one in current Transformer in busbar compartment.

Cable end compartment volume will allow current transformer easy access and removal. Current transformers shall be cast resin type. Current transformer performances shall be as per technical sheets included into the relevant Chapter.

2.6.3.10 Voltage transformers

Each Voltage transformer shall be installed in the cable end compartment, connected between the downstream pole and the cable connector through HRC fuses. Cable end compartment volume will allow voltage transformer easy access and removal.

Voltage transformers shall be cast resin type. Voltage transformer performances shall be as per technical sheets included in the relevant Chapter.

2.6.3.11 Motion and plug-in mode Special devices

All complete sets of plug-in accessories shall be provided for each type of circuit-breaker, together with four sets of auxiliary plug-ins actuating devices, where the circuit-breaker has such devices.

In addition, two hoisting devices (pulley fastened to the ceiling or any other solution) shall be provided if necessary, for the storage position and the maintenance depot.

2.6.3 33 kV / 415 V, 3 Phase Dry Type Auxiliary Transformers

The Auxiliary Transformers, also referred to as Auxiliary Station Transformers of 3-phase, 33kV/415V, 200 kVA are required as per detailed specification attached at annexure-A3 of Particular specification to supply the power requirement at 415 / 230 V of various electrical equipment, systems and appliances in the RSS. Mainly these comprise of power required for lighting, fans, air-conditioning, control and monitoring circuits, battery chargers, space heaters in the switchgear / panels etc.

Suitable capacity of RC Snubber circuit and Surge Arrester shall be installed between Phase to Ground and between phases with Surge Counter & Earthed properly.

2.6.4 Low Voltage Distribution Board (ACDB)

As per latest relevant standards (IEC 61439), this shall be "total type tested assembly"

General

The low voltage AC Distribution Board has 2 incoming feeders from the 33 kV / 415 V Auxiliary Transformers, together with a Coupling Circuit Breaker. There are several 415 V or 240 V of outgoing feeders for feeding the power required for lighting, fans, air conditioning, control and monitoring of switchgear etc in the RSS-cum-AMS-cum-TSS. However, the following is the minimum requirement in each of the cabinets: -

- (i) 4 feeders each with 25A MCB, for Control Room & AMS Building lighting, fans, air-conditioning etc.
- (ii) 3 feeders each with 25A MCB, for 66 kV Switchyard.
- (iii) 3 feeders each with 25A MCB, for Transformers * OLTC.
- (iv) 2 feeders each with 25A MCB's for 33 kV Switchgear
- (v) 2 feeders each with 25A MCB, for 25 kV Switchyard.
- (vi) 2 feeders each with 25A MCB, for Relay Panels.
- (vii) 2 feeders each with 100A MCB's for Battery Chargers
- (viii) 6 feeders each with 25A MCB, as spares.
- (ix) 1 feeder for filtration machine

The Detailed specifications for the Board refer **Annexure-A2**

2.6.5 110 V DC Power Supply System**General**

The 110V DC Power Supply system, including Battery chargers, Battery banks etc. shall cater for the entire DC power requirement of all equipment in the RSS-cum-AMS-cum-TSS complex.

Design Principles

The fundamental demand on a DC system is that it must be robust, simple and clearly arranged. The DC system shall be based on the following principles.

- High selectivity
- Main distribution board located adjacent to the battery room
- No common main fuse for battery
- DC type MCBs to be used for DC circuits.

- An installation, which is free from the risk of, short-circuits between the battery and the main distribution board.
- Fully compartmentalized between all battery charger and distribution board

The DC system shall be earthed across a high resistance resistor, so that simple earth fault shall not cause tripping of the system. The DC system shall be designed to allow unloading tests, boost charging and maintenance of each to be carried out during normal operation; this implies that provision shall be made for isolating the battery and the associated rectifier from the load.

Since the entire system cannot be designed so that short-circuit shall never occur, it must be provided with circuit protection, these shall provide absolute and safe selectivity, so that tripping is confined to the minimum. Only rapid protection characteristic may be used.

System Description

The control and monitoring circuits shall be supplied with 110 V DC via two battery chargers. In case of failure of one set, automatic changeover to the other set shall enable backing-up of the supply of the circuits normally supplied by the faulty one.

A stand-by battery charger shall permit the preventive or corrective maintenance of one of the both normal battery chargers. Its actuation shall be obtained only after putting out of service one of the concerned battery charger to be maintained.

For each one of the both 110 V DC supply set, an automatic and manual change-over system from one source to the other shall be provided and operate as follows:

Automatic Mode:

When a circuit breaker trips by lack/absence of voltage, the system switches automatically to the other source, if this one is under voltage, by closing the coupling circuit breaker.

When the voltage comes back to the normal source then after a delay (delay is to ensure that the voltage has well come back) the system switches back automatically to the normal source by closing, first, the normal circuit-breaker, then by opening the coupling circuit-breaker. The parallel between both sources shall be as short as possible.

Manual Mode Without break: In this mode it shall be necessary to choose between which apparatuses the transfer shall be made:

- First source and coupling
- Second source and coupling

It shall never be possible to make a transfer directly between the first and the second sources. The transfer shall be obtained by closing the circuit breaker which shall remain closed at the end of the operation. The opening of the other one shall be obtained automatically. The parallel between both sources shall be as short as possible, but enough to ensure a good transfer.

The equipment supplied shall be highly safe and reliable; it shall be described in detail when submitting the relevant drawings (equipment characteristics, layout plan, protections, monitoring) and it shall be guaranteed to eliminate all risks of incidents which may occur during the change-over operation from one source to the other.

The batteries shall be of insulated pole type and wired in floating voltage mode. In normal situation and for each normal battery-charger set, the charger shall supply the control and monitoring circuits and shall deliver the battery trickle charge. The third battery-charger set being in stand-by mode. In case of fade-out of the AC voltage, the battery shall immediately and without break replace the charger to ensure permanent power supply of the circuits and controls.

The entire 110 VDC distribution and the batteries shall be isolated from the earth; satisfactorily. The overall condition of this isolation shall be monitored permanently by a specific and highly reliable device. Each battery shall also ensure DC power supply to safety lighting i.e. DC operated emergency lighting upon fade-out of AC power supply sources.

Equipment Specification

The following 110 V DC source equipment shall be provided in the auxiliary room and in the battery rooms of the substation.

2.6.6 Battery

Each battery shall be of stationary compact, Nickel-Cadmium type. They shall be maintenance free. The capacity of the battery shall be decided by the PST contractor taking into account the permitted voltage tolerance of the individual loads, the power consumption of various loads, as per temperature range from -0.6°C to 50°C and the length of time they are in operation and the manner in which they draw power.

The precise capacity of battery shall be determined to ensure total autonomy of the station for 8 hours as required to retain the power supply of the standby lighting and of the control/monitoring auxiliaries in case of total failure of the AC sources.

The AC load of SAS equipment like server, gateways, printers and other accessories shall be supplied through the suitable capacity of 2 Nos. ONLINE inverter. Inverter will take DC supply from these two battery sets. Capacity of this load shall also be considered in the battery capacity.

The battery protection shall be as close as possible to the battery and shall be contained in separate enclosure for negative and positive pole respectively.

The enclosure shall be made of insulating material. The connection between the battery and its protection shall consist of single conductor and shall be run in such a manner so that they are protected from physical damage.

Each battery half shall be connected through its own battery distribution board to the main board, and each battery half section shall have its own supervisory equipment to indicate and alarm for the maximum and minimum voltage levels on float-charge and earth fault.

Suitable care must be taken that vent plugs are sturdy and reliable, and this shall be checked during Factory acceptance test.

The PST contractor shall submit performance certificate for last five years along with the Vendor proposal.

2.6.7 Battery Charger cum 110 V DC Distribution Board

The Battery Charger cum 110 V DC Distribution Board shall be Float cum Boost type suitable for charging Ni-Cd cells, fully compartmentalized with metal sheet and duly certified, accepted by the battery manufacturer. Both the chargers shall be housed in separate enclosure.AC

Power Supply:

- > Voltage: 230V/415V $\pm$ 10%
- > Frequency: 50 Hz $\pm$ 3%
- > Maximum short-circuit current: 4000 A rms.
- > Recharge to 80% of the battery capacity: 8 hours

DC Output:

- > Power supply voltage: suitable for a battery of 110 V
- > Operating period after AC supply failure: 8 hours
- > Constant power drain: shall be decided by the PST contractor , to deliver the full duty. The minimum capacity of the Battery shall not be less than 300AH.

Charger:

The charger shall comprise of an inlet transformer and silicon diode/thyristor or thyristor bridge. All electronic components shall be use of Industrial grade (Temperature range-85 deg.C) and CB should have conformal coating suitable for very heavy pollution level for Bengaluru. The PST contractor shall submit test certificate for the same along with the Vendor proposal. The regulation system shall consist of plug-in modules fitted with polarization devices. The charger shall include the following monitoring and measuring devices:

- Maximum and minimum DC voltages (threshold values to be defined)
- Charger shut-down due to an internal fault.
- General alarm for remote monitoring

The charger shall include the following control devices:

- A main On/Off switch,
- A normal/boost selector switch,
- A control deliberate discharge.

The AC and DC terminal strips shall be separated from each other. Each battery charger shall be:

- Designed to ensure operation according to the battery ratings as described below,
- Installed in a sheet cabinet with feet, closed by panels.

- Ventilation shall be natural.

a) Characteristics

Major characteristics are described in the annexed technical sheet. The chargers shall be diode and thyristors regulated type, wired as Graetz Bridge.

b) Operating and Floating Rates

The voltage at the charger current output terminals shall be automatically kept within +1% for variations of +10% / -15% of the AC voltage and of +5% of the frequency, whatever may be the output required.

The residual ripple ratio shall be as low as possible (less than 3.5%) so as not to disturb the various operating circuits.

c) Equalization Charge Operation

This charge shall be able to take place up to the floating voltage within +1% under the same conditions as above.

Automatic change-over from floating to equalization charge and conversely Following any failure of more than five minutes of the AC supply network, the charger shall automatically revert to the charge position right upon return of the voltage and shall remain on this position throughout the time set by an adjustable timer (from 1 hour to 20 hours). After this time, the charger shall return to floating operation. The charger shall remain in floating operation if the network failure is shorter than five minutes.

d) Direct Operation

The charger shall be capable of operating directly, without the battery, under the same conditions of accuracy as for the floating and charge modes.

e) Manually Controlled Operation

Operation in manual control shall be possible, i.e. it shall be possible to execute manual adjustment of the voltage in case of malfunction of the regulator.

Alarms

The status of all battery chargers shall be indicated at the AMS, as well as at the OCC (through SCADA), as per the following convention:

Green – Healthy and in-service, Yellow – Healthy and standby, Red – Defective.

The change of status from “Healthy” to “Defective” shall be accompanied by an audible alarm/hooter, both at the control room of RSS and in the OCC. However, if the AMS is unmanned, it shall be possible to annul the audible alarm function at the unmanned RSS.

f) Protections and Monitoring

The charger shall be fitted with the following protections installed at its rear:

- A device limiting the current output by the rectifier to its rated current value with sufficient capabilities of adjustment and possible pick-up of the set point value
- Switching diodes,
- Breakers with fuse elements for overall protection on the transformer primary,
- Breakers with fuse elements in series with each rectifier component (diodes and thyristors).
- Breakers for the various auxiliary circuits,
- An on/off switch controlling a three pole make-break switch with magneto-thermal protection on the AC circuit and a two pole make-break switch with magneto-thermal protection on the DC circuit.
- the specific protection to ensure satisfactory operation and protection of the set.

h) Miscellaneous

The battery charger equipment shall also include:

- A signaling light denoting the opening of the make-break switch on the AC side, controlled by the tripping of one of the Miniature Circuit Breaker protecting the various circuits of the apparatuses,
- A signaling light denoting the opening of the make-break switch on the DC side through actuation of the magneto-thermal relay,
- A digital voltmeter indicating the voltage on the DC side
- A digital ammeter which shall indicate whether the battery is under charge or the battery is only delivering the load.
- The position of the various circuit-breakers and of the protection and fault relays shall be monitored through two flip-flop stages.
- An inspection light shall be fixed inside the charger compartment, which will automatically come “on” when the charger compartment is opened for inspection. This shall be independent of the “on/off” position of battery charger and shall be operative when the 415 V supply is available to the charger.
- All light and indications lamps shall be of LED type only

i) Tests

Battery Charger shall be fully type tested as per test given in appendix-5 of the General specification and IEC60571.

j) Training

The nominated Employer Staff / engineer shall be trained to carry out in house repair and maintenance of complete battery charger including PCB's, Programming, downloading of data (if applicable), associated software and its operation as applicable. The PST contractor shall submit detailed training program for approval of employer.

2.6.8 110 V DC Distribution Board

a) Description

Distribution of the 110 V DC sources shall be gathered inside two specific cabinets, one for each half station, called DC auxiliary.

These cabinets shall be compartmenting type equipped with doors, fitted with flexible seals, close via lock-bars and on which shall be installed a mimic diagram with signaling lights denoting the position of the main apparatuses.

All control and protection including Under voltage relay of DCDB shall be realized with 110V DC control supply only.

The PST contractor shall submit details of vendors for all "brought out" items along with the vendor proposal for approval of employer.

Equipment

Each cabinet shall include the following (list not restrictive):

- Isolating switch
- Master power supply circuit breakers
- Non return diodes and set of normal/stand by supply bars
- The current and voltage protection relays
- The isolation monitoring
- Operation of Low Voltage Distribution Board shall be realized by putting the system in Auto mode or Manual mode. Selection of Auto or Manual mode shall be possible through local/OCC SCADA. Similarly, selection of Local or remote mode shall also be possible through Local/OCC SCADA.
- The coupling circuit-breaker for both 110 V DC sources

c) Outgoing Feeders

The outputs, protected by circuit-breaker, whose rating shall be selected according to the power of the installation services, corresponding to the distribution circuits intended to supply notably:

- The control, monitoring and protection devices
- The power transformer tap changers monitoring
- The auxiliaries of the fire protection installations
- The safety lighting installations
- The output circuit breaker as spare
- The signaling lights

- An interlocking device prohibiting paralleling
- The position limit switches of the main apparatuses

Provision of the signaling shall be made at the level of these cabinets of the auxiliaries section.

Training

The nominated Employer Staff / engineer shall be trained to carry out in house repair and maintenance of complete DCDB panel. The detailed Operation and maintenance manual and training program shall be submitted for approval of employer.

2.6.9 Cable Path

At the Auxiliary Main Substations, the auxiliary network shall be equipped with the following cable path:

- Between incoming circuit breakers and the corresponding main 220/132/66 kV/33 kV transformer.
- Below 33 kV cubicles connecting compartment
- Between outgoing cubicles and the viaduct
- Between the auxiliary transformer circuit-breaker cells and the corresponding auxiliary transformer
- Between the auxiliary transformer and the corresponding 415 V incoming CB board
- From the low voltage board to the various electrical ancillary devices

The position and alignments of cable paths shall firstly be such as to facilitate pulling, laying and securing of the cables and, secondly, shall not hinder access to the bus-bar box-section. Cable paths shall be linked to a ground collector.

2.6.10 Accessory Boards

An Accessory Board, containing all accessories required in an MV/ LV equipment room, shall be provided at a conspicuous place in the AMS Room. The Accessory Board which may be in the form of lockable cupboard, shall essentially contain, but not limited to

- Insulating pole Gloves
- Electrician standard toolbox, complete with all types of pliers, spanners, screw drivers, insulation tapes, testers, knife and test lamp.
- Mechanical toolbox essentially containing torque wrenches, spanners, screw drivers, rachets, hammers, lock and key sets.
- Hand-held torches.

2.6.11 Clean Agent based Indirect Fire Suppression System:

Dry type Transformers, AC distribution board (ACDB) shall be protected against fire by means of an 'Automatic Fire Detector and Extinguisher System', 'Fire trace' type or equivalent, complete with clean agent-based fire suppression system, as per detailed specification attached at Annexure-A5

2.6.12 Safety Equipment

The following Safety Equipment shall essentially be provided and kept at suitable places in the RSS.

- Fire buckets filled with clean dry sand and ready for immediate use
- Fire extinguishers suitable for dealing with electric fires.
- First aid boxes
- At least 3 gas masks
- Instructions, in Hindi and English, for restoration of persons suffering from electric shock.
- An artificial respirator in all HT substations.
- Discharge Rods 6 Nos for 220/132/66 kV, 6 Nos for 33 kV, 6 Nos for 25 kV.
- Insulated gloves
- Insulating stools
- Protecting glasses
- Body lifting pole
- Single pole voltage detection pole
- Movable earthing and short circuit equipment
- Insulated cable cutting pliers
- Notice about care to electrified peoples
- Salt to avoid kidney blocking

2.7 Traction Supply Equipment

2.7.1 Description

Traction Substation (TSS) located by the side of the Receiving Substation, performs the task of supplying the 25 kV Single Phase power to the traction overhead equipment through appropriate switchgear and protection arrangements. The TSS mainly comprises of:-

- Traction Transformer
- 25 kV, GIS SF6 indoor/AIS outdoor type for incoming, outgoing and bus coupler as per data sheet and specification mentioned elsewhere.
- Instrument transformers, as necessary for protection and measurement. All Incoming & outgoing feeders shall be protected with Lightning Arrestors of suitable ratings.
- Protection relays, measurement meters and associated devices, as necessary
- All interconnecting power cables
- Return cable connection between the traction transformer secondary earthed terminals,
- to the return current earthing arrangement in stainless steel boxes as per drawing and specifications. Provision of CTs along with meters for monitoring of return current also required. The return current monitoring shall also be available in SAS.
- All control and monitoring cables for necessary connection of equipment

- Control and relay panels and other associated equipment to make the traction substation
- fully fit to perform its task.

Traction Substation Drawings

The Single Line Diagram of the Traction Substations is shown in the drawings enclosed in Volume 5 of tender documents.

Performance Specifications

The Performance Specifications of various equipment are described in the succeeding paragraphs.

2.7.2 Traction Transformer

i) SCOPE

These specifications are applicable to Traction Transformer of 2-phase 220/132/66 kV primary voltage and 1-phase, 27.5 kV secondary voltages. Traction Transformer shall be designed for outdoor installation and for operation at frequencies of 50 Hz.

The Traction Transformer shall be complete with all Parts, Fittings, and oil for the first filling, and accessories necessary for its efficient operation, including mounting frame work of steel. All such Parts, Fittings and Accessories shall be deemed to be within the scope of this Specification, whether specifically mentioned or not. The Traction Transformer shall be of proven design.

ii) Governing Specification & Standards

The Traction Transformers shall comply with the standards of the International Electro Technical Commission (IEC60076) or equivalent Indian standards.

The Traction	Specification No.	Title of Specification
1.	IEC- 60076-1,2,3,4,5 &7	Power Transformer
2.	IEC - 60214	Tap changer for power transformer
3.	IEC- 60296	Insulating oil for Transformer
3A	IS-12463:1988 along with additional requirements of RDSO	Insulating oil for Transformer (revise for Ester Oil)
3B	IEC- 61099	Synthetic Ester Oil (SEO) for power transformers
3C	IS-16081	Synthetic Ester Oil (SEO) for power transformers
4	IS-335	Insulating oil for Transformer
5	IEC- 60028	Conductor for Insulated cable
6	IEC- 60137	Insulating Bushing for rated Voltage above 1KV
7	IEC- 617-2	Earthing terminal
8	IEC- 60721-2-5	Specification for painting: - Environmental condition
9	ISO- 12944-5	Protective Paint system

iii) Characteristics: -

The Traction Transformers at TSS shall meet the following characteristics:

- 2-phase Primary winding of 220/132/66 kV
- On load tap changer on primary windings
- Possibility of various overload conditions
- Separated oil conservator
- Cooling by natural oil circulation and banks of radiators mounted on the tank
- Both transformers shall be identical
- Transformer noise level should not exceed 75dB measured at a distance of 1.5m
- The Vector group shall be I.i.
- Should have Thermos Symphonic Filter.
- The two transformers at any Traction Substation are not meant to work in parallel.
- Oil Expansion Vessel with Air cell.

iv) Rated Power

The 220/132/66 / 27.5kV transformers shall be manufactured and guaranteed so as to perform satisfactorily with a power rating, measured across the secondary winding, of the following value under load with cooling system in operation (ONAN/ONAF mode).

S.No	Name of RSS	Cooling System	Rating (MVA)
1			
2			

v) Overload Capacity

After constant operation at continuous full load, the transformer shall have a guaranteed minimum overload capacity of:

- 50% for a duration of 15 minutes,
- 100% for a duration of 5 minutes,

After overload the temperature rise shall not be more than:

- 65°C above ambient temperature for oil.
- 75°C above ambient temperature for windings

vi) Rated Voltages

The primary winding voltage shall be 220/132/66 kV, as applicable at a power frequency of 50 Hz, on the main tapping.

Operating voltage may increase to + 10% or drop to -15% for the traction transformers. The primary winding shall be fitted with on-load tap changer offering 16 steps ensuring the primary voltage compensation from -15% to +10% of primary voltage. The secondary winding voltage shall be 27.5 kV at a power frequency of 50 Hz, one end being connected to the rails and the earth.

vii) On-Load Tap Changer

Voltage shall be substantially constant at the untapped windings (secondary windings) and variable at the tapped winding (primary winding). The category of regulation applied shall be constant-flux variable voltage type (CFVV)

The on-load tap changer shall be single-phase enclosure type, installed in a separate oil tank, offering 16 steps (+6step, normal and -9step), each representing 1.667% of the nominal voltage. The tap changer shall have the following characteristics:

- 50 000 operations without any attention
- Motor and hand-driven possibility
- Tap position indicators
- Commutation current compatible with the short duration transformer over-current.
- Diverter switches shall be designed for high-speed operation and shall be interlocked to ensure that there is no possibility of an operation stopping in mid-position. Arcing contacts shall be of tungsten alloy material.
- Devices for ease of extraction for maintenance purpose
- Manual/Automatic, Local/Remote, Control & Monitor of OLTC from RSS control room and OCC
- OLTC shall Block operation in case any of the pole gets stuck.
- Auto operation of the OLTC shall be block in case of transformer CB is in open condition.

The oil volume of the on-load tap changer unit must be separated from the tank for core and winding oil. The power circuit of the on-load tap changers shall be connected to the primary windings and shall enable the required voltage variations as mentioned in the annexed technical sheet.

The full technical description shall be given as regards power and auxiliary circuits; periodicity for checking and over hauling the power circuit shall be indicated in the transformer maintenance Manual. The servomechanism settings shall be designed and executed to avoid too many actuations.

The manufacturer shall provide mechanical and electrical diagrams. A suitable protection relay shall be connected on the oil pipe between the on-load tap changer and the expansion vessel. The voltage ratio shall be checked according to the guaranteed figures and the tolerances stipulated in the standards.

viii) Cooling System

The Traction Transformer shall be designed to operate in ONAN/ONAF mode (Oil Natural Air natural / Oil Natural Air Forced). The oil along with inhibitor to be used for the transformer must be in conformity with the IEC 296 standard or IS 335 (with latest amendments) and of the highest inflammability degree. Spare oil for at least 10% of each transformer shall be provided.

The maximum temperature allowable at nominal rating shall never exceed:

- 50°C above ambient temperature for mineral oil
- 55°C above ambient temperature for the copper winding and the iron core.

Dielectric strength of the oil during test should be more than 55 kV /2.5 mm; the PST contractor shall mention the method and the referenced standard employed. The transformer shall be rejected in case the temperature rise exceeds the guaranteed values by more than five

degrees centigrade.

The PST contractor shall give full description of the design, operation and maintenance of the proposed air-cooling system for ONAN/ONAF mode and indicate the air flows needed for ventilating the cubicle and the air cooling units: -

- For Natural Ventilation
- For Group-I assisted Ventilation
- For Group-II assisted Ventilation

In case of fire detection into the transformer cubicle, the air-cooling system shall be immediately and automatically switched off.

ix) Short-Circuit Withstand Capability

Short-Circuit On HV Side

The transformer shall be designed and constructed so as to withstand without damage, or impairment in its performances, any external short-circuit.

The primary winding of the transformer shall be designed for carrying the full symmetrical short circuit current, for 3 sec. The full symmetrical short circuit current shall be calculated in accordance with IEC after taking into account the system impedance on the primary voltage of the transformer. The design of the primary side bushings of the Transformers shall withstand the symmetrical current for three seconds during short-circuit on primary voltage as specified in IEC 60076-5. To limit the short-circuit symmetrical current to an allowable value; the impedance voltage shall never be less than twelve percent (12%). At rated power and frequency on the main tapping, the impedance voltage shall be equal to 12.5%.

Short-Circuit on LV Side

The maximum short circuit current at the output of feeder station has to be limited at 16 kA to comply with the rolling stock on board circuit breakers breaking capacity, (compared to distribution network) only limited by the internal transformer leakage impedance.

Consequently, transformers must be designed taking into account this current short circuit limit, as well as electrodynamics and thermal constraints. The PST contractor shall specify a guaranteed value and tolerances according to the standards and requirements.

x) Iron Core

The magnetic core, frame assembly, clamping and general structure of the transformer shall be mechanically sturdy so as to be capable of withstanding shocks which may happen during transport or during short-circuits and over-voltages.

Cores and magnetic circuit shall consist of cold-rolled grain-oriented silicon steel sheets of the best quality, offering every guarantee of durability, heat and oil resistance. The core tightening bolts shall be suitably insulated, and the grounding of the magnetic circuit shall employ generously sized copper connections and links.

The keying and compression of the laminations, together with the induction value, shall be designed so as to keep vibrations to a minimum and to reduce, in particular, the third and fifth harmonics influences.

Calculation sheets to establish maximum flux density (i.e. 1.55 Tesla) shall also be submitted with Design to engineer/employer. The PST contractor shall submit complete technical data

of the system to the employer.

xi) Transformer Losses

The transformers shall be designed for minimum losses.

$$PW = K * 365 * 24 * C (W_{ir} + b^2 W_{cu}) / 1000$$

Where

$$\begin{aligned} \text{Thus } PW &= 10.675 * 365 * 24 * 6.60 (W_{ir} + b^2 W_{cu}) / 1000 \\ PW &= 617.18 (W_{ir} + 0.25 W_{cu}) \end{aligned}$$

In case the transformer losses during tests are found greater than the values guaranteed in the offer, a consolidated penalty shall be paid by the PST contractor, according to the following formula (for the tolerance permissible according to IEC standard):

$$617.18(d W_{ir} + 0.25 d W_{cu})$$

Where:

- PW is the present worth (in IR) of annual capitalized cost of losses at 8% rate of interest over 25 years
- K is the present worth factor (8% interest, 25 years) = $\frac{1}{\{0.08 * (1 + 0.08)^{25}\}} = 10.675$
- C is the cost of the kWh (in Indian Rupees) = Rs. 6.60
- W_{ir} is the iron losses in Watts at normal voltage and main tapping
- W_{cu} is the full load copper losses in Watts at normal voltage and main tapping at 95°C
- b is the load factor of transformer = 50 %
- dW_{ir} and dW_{cu} are the differences between the test values of iron losses at full voltage and copper losses at full load on one transformer at main tapping and the values guaranteed in the offer.

xii) Windings

The winding conductors shall be made of best quality high conductivity electrolytic copper, in compliance with the standard (IEC 60028) requirements. Both windings, primary and secondary, shall be designed to withstand over-voltages and over-currents in case of direct short-circuit across the medium voltage terminals with the primary winding line for three seconds. Construction shall take into account electro-dynamics and thermal constraints specific to railway traction duty.

The adjustment windings shall be designed specifically to withstand direct short-circuit of all part of the adjustment turns that may occur at the contact plates of the on-load tap changer. The windings, connections and terminal links shall be properly brazed so as to withstand the shocks and vibrations that may occur during transport or short-circuit.

Tests on samples shall be carried out and results submitted for approval before starting assembly of the transformer windings. Current density for each winding shall be not more than 2.5 A/mm². The insulation material used for the transformer windings and connections shall be of class A.

xiii) Terminals and Connections

The primary and secondary connections shall be realized through porcelain/polymeric bushings insulators as applicable. The porcelain shall be brown glazed. It shall be unaffected by atmospheric conditions like fumes, ozone acids, alkaline, dust, sandstorms or rapid change in temperature between 0°C and 75°C under working conditions and the prevailing environmental conditions/changes in Bengaluru.

In order to avoid damages to tank in case of disruptive discharge, bushing base should be connected to the earth. Creepage distance for one bushing should be 31 mm/kV. Bushings shall be realized in conformity with the IEC 137 standard.

Special care shall be taken against transmission of vibrations by employing a damping system and suitable fittings. The design shall take into account the ease of overhaul. It should be possible to withdraw and to remove the transformer at ease. Interchangeability between transformers shall be achieved through the use of identical elements.

The link between secondary terminals of the transformer and the 25 kV switchgear shall be made by cables connected directly at the outside of the secondary bushing. Bushings shall be realized in conformity with the IEC 137 standard.

xiv) Tank and Radiators

The transformer tank shall be made of high-quality boiler plate steel as per IS2002 with stiffening frame and girders. The thickness of sections shall be suitably sized so that it is possible to dismantle by grinding and re-do welding at least three times, before it becomes necessary to condemn the sections and refabricate.

The thickness of the tank should not be less than 10 mm, with reinforcement in order to withstand full vacuum, and mineral oil pressure. Tank shall be connected to the earth at two different points. In case of separated radiators, they shall be earthed separately and consequently pipes network shall be mounted with insulating joints.

The tank itself, the pipe work, valves, joints and gaskets shall be airtight, watertight and oil-tight. The junction shall be capable of withstanding the temperature of a fire without causing any leak as per IEC 60076 standards. The tank shall be fitted with hooking points to enable it being lifted in balance by means of an overhead travelling crane, either as the main package or in form of the complete unit, fully equipped and filled with mineral oil.

The frame shall enable the transformer being laid normally on a slab or foundation block, without rollers. Each dismountable tank and radiators element shall be equipped with the following auxiliary devices:

- Flanged oil drainage valves,
- Oil sampling cocks at top and bottom of the tank,
- Flanged valves suitable to connect the oil filtering unit,
- Hooking points
- And overall shall be equipped with:
- Special pockets for checking by thermometers,
- Earthing terminals according to IEC 617-2 standard
- Frame to ease the transportation

- Swiveling removable rollers with locking devices.
- Overpressure relief device provided with electrical contacts
- Manholes on the tank cover so as to obtain access to the core winding
- Assembly, tap changer mechanism, terminal, the lower ends of all bushings etc. for purpose of repair without lifting the core winding assembly

Name plate to be provided with all technical particulars

xv) Oil Expansion Vessel

The transformer shall be equipped with an oil expansion air cell vessel placed above the transformer on a specific support. It shall be partitioned so as to avoid mixing between the on-load tap changer oil and the core and winding oil.

Each partition shall:

- be connected to the transformer through all the necessary pipe-works, fitted with
- flexible metal joints and gaskets; the connecting pipe shall over-extend vertically inside the vessel (at least 8 cm)
- be provided with, easy to reach, drainage valves, oil sampling devices and relief valve.
- be equipped with a self-dehydrating breather filled with "Silicate" or equivalent, permitting easy maintenance during transformer normal operation.
- be provided with an oil level indicator having auxiliary contacts and easily observable from ground level.
- > The oil volume should be above the minimum level, when the ambient temperature is 0°C or below. Similarly, the oil volume should be below the maximum level when the ambient temperature is 55°C or above

xvi) Control and Protection

The transformer shall be delivered with "Buchholz", thermal and earth fault protections, all connected to the control and monitoring cabinet

Buchholz: The term "Buchholz" protection denotes the gas-sampling device and relay for gas fault detection and storage for analysis. The relay shall comprise of two thresholds as follow:

- alarm in case of minor fault such as local overheating of windings or core (small gas discharge),
- tripping-out in case of major fault (violent gas discharge) and excessive oil leakage.

Both transformer and load-tap changer oil circuits shall be equipped with "Buchholz" protection. They shall be connected to the oil pipe between the tank and the expansion vessel, without any flat part and any less than 50 mm bend.

It shall be free for access and maintenance; a by-pass system shall be provided to enable oil flow without interrupting operation during maintenance checks. In order to ease gases chemical analysis, the gas-sampling device shall be accessible during transformer operation, at man's working level.

Thermostat: The thermostat itself shall be installed in the monitoring box, while the indicator on it facade and the thermal probe shall be installed into the tank with appropriate pocket.

xvii) Control and Monitoring Cabinets

Made of stainless steel-sheets, grade-AISI-316(2% of Mb) totally enclosed dust-proof and watertight type (IP55) suitable for outdoor applications it shall be equipped with:

a) For transformer

- Access doors with padlocks
- 415 /230 V protection and power circuits.
- 110 V dc control and monitoring relays
- Internal lighting monitored by the door position.
- Heating thermostat. with indicators and contacts
- Information terminal block
- Remote control and monitoring multi-pin connector
- Cooler Control system as per following modes:-
 - Auto/Manual
 - Local Remote
 - Fan Control

b) For On-load tap changer

- Access doors with padlocks
- 415 /230 V protection and power circuits.
- 110 V DC or 415 V AC (3 ph) or 220 V AC (1ph) motor, control and monitoring relays
- Internal lighting monitored by the door position.
- On-load tap changer operating equipment and control
- Counter
- Information terminal block
- Remote control and monitoring multi-pin connector
- OLTC tap position should operate based on voltage level of primary side voltage of Transformer. This provision shall be provided with PLC based logic and PLC should be installed in the RTCC indoor Panel and should have adjustable time & voltage settings for OLTC tap operation feature.

- Alternatively, Diverter switch with multi ratio PT arrangement may be used for OLTC operation on primary voltage sensing.
- RTCC panel should have TPI (tap position indicator) & Remote, Auto and Manual Operation of OLTC.
- Control of Auto / Manual and Local/Remote selector switch shall also be possible from OCC /Local SCADA.

All control and monitoring cabinets used in indoor shall conform to the following minimum specifications.

Material	:	Steel
Minimum thickness of Steel sheets	:	3 mm for front cover & base frame 2 mm for rear door
		1.6 mm for roof plate, bottom plate & side covers
Powder Coating :		
Exterior	:	RAL 7032, Texture finish
Interior	:	RAL 7032, Texture finish
Base frame	:	Black
Thickness	:	Min. 80 microns of Power coating

The PST contractor shall submit to the Employer, the complete details of the Control & Monitoring Cabinets, including details of the structure, process of finish and painting, wiring, terminal blocks, cubicle illumination heating etc. for Employer's approval.

The details adopted for Control and Relay panels, Bay Control and Protection units, Transformer and On-load tap changer cubicles and all other Control and Monitoring Cabinets, located inside the RSS Control Room shall be identical to project an aesthetically good appearance.

xviii) Metal Work and Paintwork

Painting should be suitable for salty seaside atmosphere and has to comply with IEC 60 721-2-5 standard. The entire surface (Internal as well as External) to be painted shall be prepared by Shot blasting to cleanliness level, SA21/2 as per ISO 8501/SIS 055900. Ensure that the cleaned surface is free of oil or grease, scales rust and other residue. Surface profile of the blasted surface should be approximately 40-60 microns.

All the external surface of the transformer shall be given first coat of Epoxy zinc rich (having minimum 83% metallic zinc) primer (Min.50 microns thickness), first intermediate coat of epoxy zinc phosphate paint (Min.60 microns thickness), intermediate coat of Epoxy high build MIO (Min.80 microns thickness), and final coat of glossy Aliphatic Acrylic polyurethane (Min.50 microns thickness). The total dry film thickness (DFT) of the paints shall be minimum 240 microns and should withstand 120°C. The shade of paint shall be gray shade 631 as per IS: 5.

All steel surfaces which are in contact with insulating oil shall be painted with heat resistant oil- insoluble insulating varnish. After baring, all metal surfaces shall receive anti-corrosion process:

- Natural stainless for Bolts & screws
- Hot dip galvanization for radiators rust-proofing and anti-corrosion paint for tank, oil expansion vessel and other metal surfaces.

The transformer and its accessories shall be completely painted in plant. The necessary touch-ups shall be executed on-site after erection. This protection shall be fully guaranteed for five years starting from provisional taking over.

Should any noticeable deterioration by rust or corrosion appear before this time elapses, the PST contractor shall be responsible for repainting at his own expense and for renewing his guarantee for the work performed. The painting and preserving of panels for transformer protection should be similar match with that of other control and relay panels provided in the control room.

xix) Particular Dispositions, Installation

Transport

For transport either by road, ship or rail, the transformer shall be filled with oil up to windings top and then with Nitrogen at recommended pressure up to the tank top or alternatively the transformer may be filled with Nitrogen, in full, during transportation.

The bushing, breather, wheels and all other external parts shall be removed on condition that they can be mounted at site. The Impact Recorder shall be mounted on every power transformer (on returnable basis). The result of the impact recorder shall be shared by the PST contractor with BSTP.

Installation

The Transformers are to be installed in Substation on two running rails, and consequently must be delivered with a set of swiveling rollers.

These rollers shall be mounted, electrically insulated from tank and with locking devices. Material layout and volume shall be such that it shall be possible to remove parts without dismantling other parts. The Insulation Resistance (IR) values shall be measured of Power Transformer before unloading and after placements on running rails. IR values between core clamps and core laminations, core to earth and clamp to earth shall be particularly required.

Material layout and volume shall be such that it shall be possible to remove parts without dismantling other parts.

Test Sheets and GTP Sheets

All type tests and routine tests of Transformer, ON load tap Changer and Bushings as per relevant IEC standards specified in technical specifications shall be carried out. Short circuit withstand test shall be conducted on one each type and rating of transformer to validate the design and quality unless such test has been conducted within last five years on the transformer of same design. In case there is change in design before five years, the new transformer design shall be validated by carrying out short circuit withstand test. All the type test report shall be valid at the time of vendor approval.

The PST contractor shall submit fully filled technical data sheet given in chapter 8B of PS along with other relevant data during technical approval.

Ester Oil Filled Transformers

If the employer requires ester oil filled transformer, the PST contractor shall submit detailed design of the transformer along with relevant extracts of applicable International/Indian standards. Any savings in size due to ester oil shall be clearly specified. The PST contractor shall submit the credentials to assist proven-ness of the design. Transformer shall be designed with thermally upgraded papers and OLTC other accessories shall be designed with high temperature rises, so as to minimize the size of the transformers. The adjustment price of transformer with synthetic ester oil is to be quoted in pricing/BOQ document (this includes the supply of spare ester oil drums in place of mineral oil, if ester oil filled transformers are chosen).

Fire Protection & Suppression System

Please refer specifications for AMT at 2.6.1

2.8 25 kV Switchgear

2.8.1 General Requirements

2.8.1.1 Operating Conditions

Equipment has to be designed to operate under:

- Outdoor tropical conditions (55° C with 95% relative humidity)
- Electromagnetic specific environment
- Plus 10% minus 15% supply voltage variations

2.8.1.2 Protections against corrosion

All metal pieces (including bolts & screws) shall be realized with stainless materials. Stainless could be obtained:

- Using natural stainless material
- By hot dip galvanizing

2.8.1.3 Earthing

All non-live metal parts including support shall be connected to the earthing collector, which shall have sufficient section to respect short circuit constraints and shall be corrosion protected and labelled in conformity with the IEC standard 617-2.

2.8.1.4 Paint Work

Painting should be suitable for salty seaside atmosphere, and has to comply with IEC 60 721-2 & 5

After baring, all metal surfaces shall receive anti-corrosion process:

- Natural stainless for bolts & screws and support
- Rust-proofing and anti-corrosive-paint for other metal surfaces

Then all metal surfaces shall be painted in accordance with the rules of art with three coats of non-metallic paint of the same quality as prescribed for outdoor transformers, total thickness should not be less than 120 µm.

2.8.2 25 kV Circuit Breakers

Proper Quality assurance plan and method statement shall be developed by manufacturer in consultation with the Employer for Manufacturing, Installation, Testing and Commissioning of the Circuit Breakers. The installation, Testing and commission shall be carried out under supervision of supplier and shall be certified for proper installation by galvanizing. Training to the Employer Staff shall be imparted for carrying out Periodic Overhaul (POH) of Circuit Breaker along with all documentation for setting up of POH facility by BSTP.

2.8.2.1 Mounting

The 25 kV Circuit breakers are mounted on steel structures, electrically linked. The steel structure for mounting shall be in accordance with IEC standards

The Circuit breaker shall be at pole top level and control equipment at hand level.

It shall consist of:

- 1 apparatus, at a minimum of 3.8 meter from ground
- A motorized and manual operation and monitoring box,
- A transmitting mechanism.

All pieces should withstand 10 000 operations without any damage.

2.8.2.2 Apparatus

Each Circuit Breaker shall be SF6 or Vacuum type and shall include:

- Up & down stream connectors
- Life sealed unit pole
- Energy accumulation type actuation system (proven electromechanical springs actuated mechanism)
- Electric and manual arming capability (Tripping and closing coils motor...)
- Under-voltage tripping coil (Auxiliary voltage off)
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable

All circuit-breakers shall follow the same electrical and mechanical characteristics and must be in accordance with IEC standards 62271-100 or RDSO's standard ETS/PSI/116(4/88) with latest modifications.

2.8.2.2.1 SF6 type

The current rupturing part consists of a couple of moving and fixed contacts embedded in a body fastened on cast resin material or hard porcelain brown glazed insulated at 52 kV (according to the IEC 273), and the moving contact is connected by means of slipping contact.

SF6 type allows damping cut out operation by mean of internal arcing during the rupture, and avoids any hard over voltage on line. A suitable device shall be provided which will ensure permanent monitoring of gas pressure inside the compartment, triggering a dual alarm threshold annunciation system in the event of drop in gas pressure. The thresholds shall have the following definitions.

- Initial alarm threshold
 - Performance of the CB is unaffected, in particular breaking capabilities remain intact.
 - Immediate intervention by specialist is not necessary.
- Second alarm threshold
 - CB tripping and locked until SF6 refilling
 - Isolating capabilities of the CB remain intact.
 - Immediate intervention by specialist is necessary.
 - Control orders are inactive.

2.8.2.2.2 Vacuum type

The current rupturing part consists of a vacuum bottle embedded in silicon rubber to prevent water condensation.

Bottle is fastened on hard porcelain brown glazed insulated at 52 kV (according to the IEC 273), and the moving contact is connected by means of flexible copper braid.

2.8.2.2.3 Common aspects

Operation of the main contact is obtained by means of so called "dead point" mechanism by which the main contact is locked in the closed position with the necessary contact force.

Opening of the contacts is obtained by releasing the dead point lock using 2 traction springs to retract the mobile contact to the open position.

The operating mechanism is enclosed within a light alloy ventilate housing which also contains one of the high voltage contacts and the flexible conductor connecting the moving contact of the vacuum bottle to the high voltage terminal.

2.8.2.3 Control Box

Mounted on the pole at hand level ($\square$ 1.2m), it shall be made of stainless steel-sheets ASI316 (2% of Mb), totally enclosed, dust-proof and watertight type (IP55), equipped with:

- Access doors with padlocks
- 415/230 V heating device.
- 110 V DC control and monitoring relays and motors
- Remote control and monitoring multi-pin connector.
- Internal lighting controlled by door position
- 230 V AC plug
- 3 positions switch (Remote / local / manual)
- Handle (Facade or beside)
- Label (Facade)

Note:

- Any handle operation shall disable motor supply.
- All equipment shall withstand power frequency test at 2000 V 50Hz / 1mn.

Box should be delivered with 4 pre-drilled cable path 30 mm and a releasing coil free space
The earthing connector shall be located externally.

2.8.2.4 Transmitting Mechanism

The transmitting mechanism materials (tubes, articulations, etc.) shall be able to withstand 10 000 operations without any maintenance (except greasing).

2.8.3 25 kV Isolators

Proper Quality assurance plan shall be developed by manufacturer to avoid misalignment during manufacturing and installation of Isolators in consultation with the Employer. The installation shall be carried out under supervision of supplier Or shall be certified for proper installation by the OEM.

As a part of quality assurance plan minimum following shall be ensured at the time of installation.

- Surface contact resistance of every isolator should be recorded in closed condition, before commissioning which has to be ensured within limits after improving alignment and surface contact area (if required).
- All nut bolts of isolator should be tightened with torque wrench only.
- There should be a gap of 500mm between male & female contact of the isolator when in open condition.
- Provision of arcing horns must be ensured at the time of installation.
- During the initial period after installation, temperature of contact should be monitored through Thermo, vision camera and condition of contact should be checked up for any welding / overheating sign.

2.8.3.1 Mounting

The Isolators are mounted on steel structures. The steel structure for mounting shall be in accordance with IEC Standards. The Isolator shall be mounted at pole top level and control equipment at hand level.

It shall consist of:

- 1 apparatus, at a minimum of 3.8 meter from ground
- a motorized and manual operation and monitoring box,
- a transmitting mechanism.

All pieces should withstand 10 000 operations without any damage.

2.8.3.2 Apparatus

Each Isolator shall be air insulated type and shall include:

- Up & down stream connectors
- Vertical break
- Electric operation where required and manual operating capability (closing coils motor...)
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable

All isolators shall follow the same electrical and mechanical characteristics and must be in accordance with IEC standards 129 or RDSO's specification ETI/PSI/ 122 (3/89)

All apparatuses up and down stream connectors shall be made of pre-drilled copper plates in order to receive 2 x 240mm² copper cable each.

2.8.3.3 Control Box

Mounted on the pole at hand level (□ 1.2m), it shall be made of stainless steel-sheets ASI316 (2% of Mb), totally enclosed, dust-proof and watertight type (IP55), equipped with:

- Access doors with padlocks
- 415/230 V heating device.
- 110 V DC control and monitoring relays and motors
- Remote control and monitoring multi-pin connector.
- Internal lighting controlled by door position
- 230 V AC plug
- 3 positions switch (Remote / local / manual)
- Handle (Facade or beside)
- Label (Facade)

Note:

- Any handle operation shall disable motor supply.
- All equipment shall withstand power frequency test at 2000 V 50Hz / 1mn. Box should be delivered with 4 pre-drilled cable path 30 mm and a releasing coil free space. The earthing connector shall be located externally

2.8.3.4 Transmitting Mechanism

The transmitting mechanism materials (tubes, articulations, etc.) shall be able to withstand 10 000 operations without any maintenance (except greasing).

2.8.4 Lightning arresters

Each Outgoing feeders shall be provided with polymeric Lightning arresters as per IEC 60099-1. The LA shall be selected from RDSO and CORE, Allahabad approved vendor list only.

These are made to protect the transformers and 25kV cables against operating over-voltage and, eventually, against lightning impulses on OHE. For this reason, they shall be installed immediately upstream feeding post isolators inside the TSS.

They shall be zinc-oxide types and they shall contain a string of resistor, whose active part shall be composed of perfectly homogenous resistors.

The polymeric enclosure shall be with long creepage distance to ensure good insulation with a high-level pollution with caged or wrapped type construction with no gas volume to ensure that surge arrester does not explode during short circuits.

They shall correspond to the class discharge 2 of the IEC 60099-4. (Minimum discharge capability – 6 kJ/kV at U_c)

A surge counter shall be communicable type, which can be integrated with BSTP/OCC SCADA installed on each lightning arrester to indicate the number of functioning of each device. They shall also indicate the value of the leakage current. The Surge Counter shall be electronic type, compatible with all makes of surge arresters. The Surge Counter shall not have any metal oxide blocks which can degrade during usage and add additional residual voltage.

Lightening arrester shall be capable of discharging energy equipment to class 2 of IEC for a 25kV system on two successive operations followed immediately by 50Hz energization with a sequential voltage profile as specified below.

42kV for 1 second

41kV for 10 seconds

39kV for 100

seconds

They shall be well insulated and shall be suitable for outdoor use.

2.8.5 Indoor 25 kV Gas Insulated Switchgear (GIS)

i) Scope of Work

The scope of work comprises of design verification, manufacture, shop testing, supply, delivery at site, installation, testing and commissioning supervision of 1-phase, 27.5kV service voltage, (Rated Voltage **27.5kV**), 2000A, 16 kA for 3 sec Gas Insulated Indoor Type Switchgear. The supply will include all supporting structures, auxiliary equipment, mechanical linkage, spring drive, SF6 gas piping, auxiliary circuit wiring, interlocking devices, current and voltage transformers, cable End boxes, meters and other accessories. The scope of work includes the following:-

a) Incomer Bay each Consisting of:

- Circuit Breaker – 1 No.
- Current Transformer – 1 No.
- Disconnecter with Earth Switch – 1 No.
- Voltage Transformer – 1 No.
- Indoor lightning arrester -1No with surge arrester counter on GIS and having SCADA communicability on IEC 61850 protocol. They shall also indicate the value of the leakage current
- Other items as required for connection to the Bus bars, Incoming cables through lightning arrester and for completing the intent of work.

b) Outgoing Feeder Bay Each Consisting of

- Circuit Breaker – 1 No.
- Current Transformer – 1 No.
- Disconnecter with Earth Switch – 1 No.
- Voltage Transformer – 1 No.
- Indoor lightning arrester -1No with surge arrester counter on GIS and having SCADA communicability on IEC 61850 protocol. They shall also indicate the value of the leakage current
- Other items as required for connection to the Bus bars, Outgoing cables through lightning arrester and for completing the intent of work.

c) Bus Coupler (1 No.)

- Circuit Breaker – 1 No.
- Disconnecter with Earth Switch – 2 No.
- Voltage Transformer – 2 No.
- Other items as required for connection to the Bus bars.

d) Bus Bars for Single Bus Arrangement**ii) Main features required:**

- a) The 27.5kV equipment shall be built according to the relevant IEC/EN standards.
- b) Unless indicated otherwise herein, all equipment supplied and installed shall comply with the IEC/EN standards.
- c) Bus zone wise busbar segregation should be provided with gas monitoring system for each bus zone.
- d) Individual Pressure gauge to be provided for each circuit breaker compartment installed at the front of the panel in order to supervise the SF6 Gas Pressure.
- e) Internal insulation level between live part and earth when the pressure of gas goes to the atmospheric pressure should not be less than 1.2*27.5kV
- f) The metal enclosures for SF6 gas insulated equipment/module shall be made from material which does not require protective painting either internal or external switchgear.
- g) GIS supplier should have supplied similar GIS for any metro/rail system. This shall be explained in tender's technical proposal. The tender will be required to explain availability of spares and services from technically trained manpower in India to support the ultimate customer BSTP in future.
- h) The incoming (single core) cable feeder shall be of suitable size as per Traction Transformer capacity. The termination arrangement shall be designed for such cables. The outgoing connections from GIS shall also be cable.
- i) The disconnecter and earthing switches shall be mechanically interlocked against mal-operation. Feeder earthing switch shall be isolated from earthed enclosures and shall permit testing of switchgear. It shall also be possible to carry out high pot DC testing of Cable core without disconnecting the cables.
- j) The conductors/bus bars shall be of copper and enclosure shall be made of corrosion resistant metal.
- k) The gas barrier insulation between compartments shall withstand 1.5 times maximum rated pressure on one side and vacuum on the other side.
- l) All gas sampling shall be possible during normal operation and without loss of gas.

- m) Loss of gas per annum shall not exceed 1% by weight in each compartment.
- n) Adequate burden/capacity shall be available in instrument transformers to permit provision of protection/measuring equipment. The instrument transformers shall have separate metering cores to permit measurement of values of energy, power, current and voltage as per required accuracy.
- o) VTs should be pluggable type (no external VT is acceptable) and provision should be available to manually disconnect the VTs from the circuit without the need to take associated circuit breaker or busbar out of service and the status of same shall be available with SCADA.
- p) Clear visual indication of Isolator and earthing switch, whether open or closed shall be provided.
- q) The Switchgear panel should be of modular design with a flanged connection between circuit breaker and busbar compartment.
- r) Control cubical shall be conventional type (push button/TNC switch for equipment operation) Interrupting Medium for Circuit breaker shall be Vacuum/ SF6. The actuating drive should be spring drive. To give the highest reliability of the system, following loss of supply voltage the operating mechanism shall have local stored energy sufficient for duty cycle of O- 0.3s-CO-15s -CO without the need of recharging. The circuit breaker shall be provided with an anti-pumping coil for all the command going to the switchgear. All interlock and auxiliary system within the actuation system shall be designed so that the circuit breaker execute its operation only when it is in a position enabling to do so completely and reliably.
- s) The isolator shall be fitted with a suitable power actuation system backed up by an emergency manual actuation in case of mal function of the former. The isolator shall not change position under the effect of electro dynamic loads.
- t) In case of any replacement or extension of switchgear panels at site it should be possible to replace or add a fully assembled circuit breaker without interfering the operation of the adjacent feeder as well as without any bus zone degassing. All circuit breaker of same rating should be interchangeable.

iii) Monitoring of Gas in the enclosure:

- Each gas compartment and each bus zone should have its own temperature compensated density indicator featuring 3 auxiliary contacts for alarm.
- The protection devices for the equipment shall ensure permanent monitoring of gas pressure inside each compartment by means of temperature compensated monitoring devices triggering a dual alarm threshold annunciation system in the event of gas pressure drops.
- The design of the cable termination shall allow plugging and unplugging the HV cable without need of opening the GIS and without any gas filling.
- The complete GIS equipment shall meet the requirements of IEC/EN standard. The modules individually as well as assembly subject to various routine test including type

test. Site test shall include leakage test, moisture contents in dielectric medium and power frequency test.

- Earthing: Entire metallic enclosure shall be bonded and effectively earthed.
- The switchgear is used for controlling 25kV OHE feeder and 25kV cable. Vendor to confirm suitability of equipment for this application and also confirm maximum over voltage during switching operation.
- In case protection is included in the scope, vendor is responsible for selection of proper relays, CT/PT application check, co-ordination of relay setting and all assistance during integrated testing. The CTs shall be located above the HV cable termination socket.

a) Cable Termination Kit:

Confirmation of incomer cable size would be made available to the vendor at the time of manufacturing clearance. However, the termination arrangement for incoming feeders shall be designed for 630sq.mm Cu. cables.

- The cable entry shall be vertically from underneath the panel.
- Outgoing feeders are two runs of 240 sq.mm copper / 400 sq.mm Aluminum cable.

Along with bid vendor to submit SLD and the GA drawing indicating the space requirement (length x depth) and the minimum clearance required in front of the cubicle and back side from the operation/maintenance consideration.

2.9 Instrument Transformers

2.9.1 General

These voltage or current transformers shall be masts mounted or mounted on steel structures in switchgear.

All measuring transformers shall follow the same electrical and mechanical characteristics and must be in accordance with IEC 61869 CT and VT or RDSO's specifications ETI/PSI/117(7/88), PSI 3156 of 1992.

2.9.2 Transformers

Each transformer will consist of primary connectors, live-insulated transformer, and a connecting box.

All unconnected metal part shall be linked to the earth.

2.9.2.1 Voltage transformers

Primary connectors

27.5kV connectors shall be made of bronze pipe □20, length

60mm. Secondary connecting box

Secondary winding connection will be realized through a dust-proof and water tight type (IP55) connecting box fitted with a 6.3 A fuse and able to receive 2x10mm² screen-cable

This cable will enter the connecting box through a cable

seal. **Transformer**

Voltage transformer 27500/110 V shall be dry resin and shall ensure that self-heating shall be less than 1°C per hour. The self-heating has to comply with the climatic conditions defined in General Conditions.

The maximum temperature rises should be in accordance with the insulation medium, as defined in the IEC standard 61869:

The core shall be built up of high-grade cold rolled grain oriented non-ageing steel laminations

One end of primary windings shall be connected to the catenary and the other end to the earth collector.

Secondary windings shall be connected to the auxiliary networks via the connecting box.

Support shall be pre-drilled for pole fixation and fitted with carrying devices (hook or ring).

Note:

1. The internal wiring / cable size will be based on OEM design/load calculations.
2. MCB can be accepted with approved type Tests and proven technology.

2.9.2.2 Current transformers

Primary connectors

Consist of up & down stream connectors, made of pre-drilled copper plates in order to receive connector fittings rated at 1250 Amps for 2 x 240mm² cable or bus bar connection. The connectors shall be able to handle at least 2400A for 5 min without overheating.

Secondary connecting box

Secondary winding connection will be realized through a dust-proof and water tight type (IP55) connecting box and able to receive 2x10mm² copper screen-cable. This cable will enter the connecting box through a cable seal.

Transformer

Current transformers shall be dry resin, and shall ensure that self-heating shall be less than 1°C per hour

The self-heating has to comply with the climatic conditions defined in General Conditions

The maximum temperature rises should be in accordance with the insulation medium, as defined in the IEC standard 61869.

The core shall be built up of high-grade cold rolled grain oriented non-ageing steel laminations

Note:

3. The internal wiring / cable size will be based on OEM design/load calculations.
4. MCB can be accepted with approved type Tests and proven technology.

3. PROTECTIONS CONTROL & MONITORING

3.1 General

3.1.1 Definition

The purpose of the protection equipment is to ensure isolation or de-energizing of equipment whose operating conditions have become abnormal to avoid:

- Any major repercussions on the traffic
- Any damages or dangerous effects on person and equipment.

All equipment shall be protected as per Protection philosophy described in this chapter and equipment protection implementations at all voltage levels (220/110/66 kV, 33 kV, 25 kV & LT) are described in their respective clauses.

The RSS PST contractor shall interface with the main traction PST contractor to meet the functional requirements of the protection system. All the instantaneous relays should be capable of operating the circuit breaker within duration of (70-110) ms from the occurrence of the fault. This time duration should include the dead time of the relays (20-30 ms), MTR (10-20 ms) & Circuit Breaker (40-60 ms) and this feature should be demonstrated during testing of the relays.

CB opening signal and MTR operating signal shall be assigned in Disturbance Recorder in all relays.

3.1.2 Performances Required

The protection system based on modular sets must comply with a high-performance standard regarding:

Reliability

This criterion defines the mean time between failures (MTBF) which has to be calculated for about 10 years.

i) Maintainability

This criterion represents the mean time for repairing (MTTR) and has to be considered only by replacement of faulty function or sub assembly.

The MTTR does not exceed 2 hours not including the dead time to reach the site. 48 hrs for outdoor agency or 12 hrs for Bengaluru based agency.

ii) Availability

This is expressed in terms of ratio using the formula:

$$\frac{MTBF}{MTBF + MTTR} \%$$

and has to represent a level of 99.95 %.

iii) Safety of Operation

Safety is ensured by the means of Cyclic self-test, ensuring general supervision on software of equipment. In case of fault, a watchdog is activated. All of inputs are insulated in galvanic and capacitive view and complemented.

iv) Electro Magnetic Compatibility

v) Due to the consequent interference level inside RSS, protection equipment has to present sufficient level of immunity defined by the following standards:

- IEC 61000-4-2 Class 3,
- IEC 61000-4-4 Class 4,
- IEC 61000-4-5 Class 3.

Such criteria shall be obtained by using either numerical type relays or specifics PLC cards.

3.1.3 Protection Descriptions

A distinction shall be made between the following cases: -

i) Hydraulic or Thermal Protections

These protections, such as lack of pressure or abnormal temperature, shall include measuring elements situated on the protected apparatus, actuating a contact (mandatory of flip-flop type) which represents the start of the protection line.

Note: Hydraulic or thermal protection can be used based on OEM design as applicable.

ii) Electrical Protections**a) Protections through lack of monitoring voltage**

Each cut-out apparatus shall include a device controlling its opening and preventing it of phase - phase from any re-closing in case of lack of monitoring voltage.

b) Protections through lack of AC voltage

Ensured by means voltage measurements with adjustable threshold, possibly associated to time delay, adjustable as well. The measurement shall be supplied from the secondary of the voltage transformers.

c) Protection against phase-phase short-circuits

Ensured by means of current relays (primary current measurement relays with adjustable threshold, associated to time delay also with adjustable threshold). The current relay shall be supplied from the secondary of the current transformers.

d) Over current protections

This function ensures the tripping of concerned circuit breaker when the current value exceeds the highest allowable load on the network in instantaneous or delayed time conditions. Following the network configuration, pre-set tripping thresholds could be commuted via automatic interlocking or voluntary action.

Tripping curves characteristics could be:

- > At constant time,
- > At dependent time following a characteristic:

- Inverse,
- Very inverse,
- Extremely inverse.

The relays display should be able to show fault records (fault current, tripping time, voltage etc.) for every phase.

e) Protection against zero sequence faults

At the output level, these shall be ensured by means of zero sequence current measuring relays (obtained through associating of the currents from the current transformers). These relays shall not be affected by the capacitive currents in the cables during unbalanced operating times which occur on the power supply (such as earthing fault of the other cables, etc.).

f) Differential protections

Based on the instantaneous comparison, for each phase, between the bar set or transformer incoming current and outgoing current, through current transformers.

g) Synchro-coupler relay

This relay shall ensure authorization of closing a coupling apparatus. Its own functioning shall come into service, only in the case of voltage presence on the both parts of the coupling apparatus.

When into service, it shall compare the phase, the frequency and the voltage of the both sources to be coupled. Phase difference, frequency difference and voltage difference shall be settable

h) SF6 Pressure Protection

This protection system shall ensure constant monitoring of gas (SF6) pressure inside each compartment and shall trigger a dual alarm threshold communication system when the gas pressure drops.

i) Presence of voltage

Voltage relay shall be used to authorize the operation of the incoming isolators and earthing isolators on no load, wherever required.

j) Staging of the protections

Selectivity of the protection arrangements shall be provided so as to avoid all unwanted tripping. The time delay of the various circuit breakers shall be suitably set so as to ensure chronological selectivity of the tripping.

The supplier shall define precisely the minimum intervals between the various protection stages, accounting for the timings and for the actuation times of each one of the apparatuses involved. A logic selectivity system shall be incorporated wherever required. To avoid unwanted tripping, it shall be necessary, in particular, to take into account transient phenomena such as energizing of transformers and engagement of cables, etc.

PST contractor shall be required to develop protection scheme for the RSS/TSS/AMS.

Scheme and relay setting proposed should be developed keeping into view of the 25 kV and 33 kV system of BSTP network in line and stations. All relay setting shall be calculated as per the fault level at each and every node in the network.

All unit protections, such as REF, Differential, Bus bar Differential protection etc., must be tested for stability.

All protection scheme, calculation, settings, tests reports, relay manual, data cables, relay software, Laptop shall be furnished to BSTP before commissioning

The RSS PST contractor is required to coordinate with the Traction PST contractor and Power Supply authority for preparation of protection scheme and relay settings.

Refer Annexure-A7 for Control and Monitoring Signals (I/O List for SCADA)

All equipment and the system should be manufactured and installed incorporating all the respective signals and commands in this list, which is minimum but not limiting

3.2 High Voltage Protection

3.2.1 Incomer Line Protection

Following section details the technical specifications for the 220/132/66 kV Incomer feeder to BSTP receiving Substation from KPTCL. Income from KPTCL shall have the following Main Protections: -

- > Integrated Differential Protection cum Line Distance Protection for 220/132/66 kV cables.
- > Backup O/C(50/51) & E/F(50N/51N) protection (Both time delayed and Instantaneous)
- > Under voltage protection (27)/ Over voltage protection (59)

3.2.2 Line Differential Protection

- The line Differential Protection IED (Intelligent Electronic Device) protection relay should be Numerical with full compliance to IEC 61850 standards in every respect and Interoperability with other manufacturers IEDs and tools should be verified.
- The IED shall be suitable for Protection, control and monitoring of overhead lines and cables for all Voltage levels in solidly or impedance grounded networks. The Protection unit should be based on Phase segregated Line differential Principle and use advanced and proven algorithms and shall support user friendly Engineering tool and Disturbance handling tool.
- It should be possible to integrate Protection and control functionality for several objects in the IED. The IED shall have complete functionality for single and multi-breaker arrangements with single or three phase tripping.
- At least four independent parameter setting groups shall be included. ED shall have extensive self-supervision including analogue channels.
- It shall be possible to equip the IED with a HMI for local access of all information. A
- Restrained dual Bias operate characteristic shall be used and the highest phase current in any line shall be utilized as bias current
- Charging current compensation for increased sensitivity for long lines and cables shall be included. The IED should be suitable for multiplexed, route switched or dedicated fibre networks.
- The communication channel shall be continuously monitored and an automatic

switchover to a redundant channel shall be possible. IED shall be provided with programmable logic for tripping and indications as well as a high. For Line differential communication it shall be possible to select between a master-master system or master slave system depending on the functional or economical requirements. An automatic changeover to Master-slave communication should take place if an interruption occurs in communication channel in master-master communication system.

- The line Differential Protection IED shall also have the distance protection scheme with the features and vice-versa. A backup high speed full scheme distance protection with at least three zones should be possible to include in order to get fault clearance in case of communication failure, it shall be possible to have the distance protection continuously in operation or only released for operation at communication failure. The distance Protection shall have characteristics that will give load encroachment discrimination and load current compensation of the reactance line in the first zone to avoid overreach. It should be possible to set the distance Protection zone in forward, reverse or non-directional mode. Each zone should have individual resistive and reactive reach settings. Separate phase selection logic and automatic switch onto fault logic should be included.
- Disturbance recording, event recording shall be built in features and included in the IED.
- IED Shall be provided with a front mounted HMI and front port for connection to a Personal Computer. The IED shall be provided with communication interface for connection to substation automation as per IEC 61850 standards. Power supply modules from 48V to 250V AC/DC shall be available.

1.2.3 Line Distance Protection

- A backup high speed full scheme distance protection with at least three zones should be possible to include in order together fault clearance in case of communication failure, it shall be possible to have the distance protection continuously in operation or only released for operation at communication failure.
- The distance Protection shall have characteristics that will give load encroachment discrimination and load current compensation of the reactance line in the first zone to avoid overreach. It should be possible to set the distance Protection zone in forward, reverse or non-directional mode. Each zone should have individual resistive and reactive reach settings. Separate phase selection logic and automatic switch onto fault logic should be included. The IED shall have full compliance to IEC 61850 standards in every respect. The IED should have feature of line differential protection.

3.2.4 Backup O/C (50/51) & E/F (50N/51N) Protection

- shall have three over current Elements (At least two stage DMT protection)
- shall be of Numerical type with full compliance to IEC 61850 standards
- shall have facility to select any type inverse characteristics as per IEC to suit requirement.
- shall have separate High set element for instantaneous function.
- Built in configuration logic to assign inputs/outputs to any functions.
- IED shall have LED for relay healthiness & unhealthiness
- Harmonic Inrush Protection feature

Integration of Backup O/C Protection within the Bay Control Unit (IED) will be acceptable.

3.2.5 Bus Bar Protection

BSTP receiving substations (220/132/66 kV) shall be equipped with a full-fledged Busbar protection system with following technical specifications.

- Numerical busbar differential protection scheme with full compliance to IEC 61850 standards shall be provided for each main bus at the receiving substation.
- Bus bar protection for each busbar shall incorporate a main protection and check feature.
- Each Bus Bar protection scheme shall have maximum operating time up to trip impulse to trip relay for all types of faults of 25 ms at 5 times setting value.
- operate selectively for each bus bar
- Give hundred percent security up to 31.5 kA fault level for 132 kV.
- incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm
- Not give false operation during normal load flow in bus bars.
- Incorporate clear zone indication.
- be of phase segregated and triple pole type
- Provide independent zones of protection.
- include individual high speed electrically reset tripping relays for each feeder
- be transient free in operation
- Include continuous D.C. supplies supervision.
- Not cause tripping for the differential current below the load current of heaviest loaded feeder.
- CT switching and External Zone formation is not acceptable.
- have provision of bypass key switch.
- have separate MTR
- include trip relays, CT switching relays (if applicable), auxiliary CT's (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus
- arrangement i.e. for all the bay or breakers under this specification as well as for the future bays as per the Single line diagram for new substations.
- shall incorporate continuous supervision for CT secondary's and shall render the relevant zones of protection in operative against possible open circuit and protection transferred to check zone only.

Common Reset push Button and bypass switch should be provided in Bus bar differential protection panel

- Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.
- The Bus Bar protection relays shall be equipped with built-in DR and Event recorder
- IED shall have LED for relay healthiness & unhealthiness

3.3 Transformer Protection

3.3.1 Auxiliary Main Transformer: -

Auxiliary Main Station (AMS) for different voltage levels will be provided with the following Protections

- Biased Differential Protection (87T)
- HV&LV Restricted earthfault Protection (64R HV & 64R LV)
- Standby earthfault Protection SEF (51G)
- Backup IDMT and two stage DMT O/C & E/F protection
- Tank Protection (64) shall be replaced with REF protection.
- Harmonic Inrush protection
- Transformer trouble signals (Buchholz, fire protection, OTT, WTT, PRD etc.) shall be implemented through Master Trip Relay (MTR)

3.3.2 Traction Transformer: -

Traction Transformer for different voltage levels will be provided with the following Protections:

-

- Biased Differential Protection (87T)
- Backup IDMT and two stage DMT O/C protection
- Tank Protection (64) shall be replaced REF protection (64R).
- Transformer trouble signals (Buchholz, fire protection, OTT, WTT, PRD etc.) shall be
- Implemented through Master Trip Relay (MTR)
- Harmonic Inrush Protection

Detail description of Transformer Protection is as under:-

a) Transformer Differential Protection (For AMT & TT)

Transformer Differential Protection shall be based on Numerical relay technology, conforming to IEC 61850 standard and shall be suitable for protection and monitoring of 3-phase AMS Transformers and single-phase traction transformers. It shall have the following features:

- be triple pole type, with faulty phase identification/ indication
- One IED shall be designed to operate correctly over a wide range of frequency range in order to cope with Power system frequency variations during disturbances.
- IED shall be based on advanced and proven algorithms to handle multitude of

application and shall support user friendly Engineering tool and disturbance handling tool.

- It shall be possible to integrate the Protections functions for Transformer into one IED.
- The IED shall have extensive self-supervision including analogue channels. The configuration of the IED shall be such that it will suit most applications and if needed the same shall be modified easily.
- Transformer differential Protection with short operate time shall be included and shall have automatic ratio matching the vector group compensation. Use of Interposing CT's for ratio correction will not be acceptable.
- Second harmonic restraint features shall be included in order to avoid tripping at inrush currents.
- Fifth harmonic restraint feature shall be included to avoid tripping at over excitation condition.
- Adaptive stabilization for system recovery inrush and Ct saturation at external faults shall be included. The IED should utilize a measuring principle that gives high sensitivity for turn-to-turn faults.
- High or low impedance based restricted earth fault protection with short operate time and high sensitivity shall be available within the IED.
- It shall be possible to include Backup Protection functions such as instantaneous over current functions for phase and earth faults and time delayed non directional over current functions with inverse and definite time characteristic with at least two steps for phase and earth faults.
- Other current functions such as thermal overload alarm based on thermal model and trip steps shall be possible to include within the IED.
- The IED shall be provided with programmable logic for tripping and indications as well as high number of logic blocks and timers for adaptation.
- IED should have built in disturbance recorder and event recorder.
- IED shall have LED for relay healthiness & unhealthiness

b) HV & LV Restricted Earth Fault Protection

Restricted earth fault Protection will be based on Numerical technology and shall have following features :-

- be single pole type
- be of current/voltage operated high impedance type
- have a current setting range of 10-40% of 1 Amp. / Have a suitable voltage setting range.
- be tuned to the system frequency
- be used for HV and LV winding wherever applicable.

c) Standby Earth Protection (For AMT)

- have Non directional earth fault protection with IDMT characteristic with a definite

minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current.

- Shall be numerical type

NOTE: Integration of following Protections of Transformers into one Protection unit IED is acceptable

- Transformer Differential protection
- Restricted earth fault Protection
- Standby earth fault Protection

d) Backup O/C Protection (both time delayed and Instantaneous) (For AMT & TT)

- shall have three over current Elements
- shall be of Numerical type with full compliance to IEC 61850 standards
- have facility to select any type inverse characteristics as per IEC to suit requirement.
- Shall have separate High set element for instantaneous function.
- Built in configuration logic to assign inputs/outputs to any functions.

Integration of Backup O/C Protection within the Bay Control Unit (IED) will be acceptable.

3.4 Bus Coupler

Following sections detail the technical specifications for both Bus coupler circuit at the Receiving substation.

- Backup O/C protection (Both time delayed and Instantaneous)
- shall have three over current Elements
- shall be of Numerical type with full compliance to IEC 61850 standards
- have facility to select any type inverse characteristics as per IEC to suit requirement.
- Shall have separate High set element for instantaneous function.
- Built in configuration logic to assign inputs/outputs to any functions.

Integration of Backup O/C Protection within the Bay Control Unit (IED) will be acceptable.

3.5 33 kV Protections.

General Definition

For the general definition, performances and description of the protections please refer to above clauses.

3.5.133 kV AMS Incomer Circuit Breaker

(LBCB) The protection of this circuit shall consist of:-

- F 50: Instantaneous over current protection
- F 51: Two stage Time delayed over current protection

- F50 N: Instantaneous earth fault protection (zero sequence)
- F51 N: Two stage Time delayed earth fault protection (zero sequence)
- Under voltage Protection with time delay (27)

3.5.233 kV AMS Coupling Circuit Breaker

(LBCCB) The protection of this circuit shall consist of:

- F 50: Instantaneous over current protection
- F 51: Two stage Time delayed over current protection
- F50 N: Instantaneous earth fault protection (zero sequence)
- F51 N: Two stage Time delayed earth fault protection (zero sequence)

This circuit shall include also a synchronism check device, which shall measure:

- The voltage difference between both sources
- The phase unbalance between both sources
- The phase correspondence between both sources

Moreover, in case of lack of voltage on one source, the device shall authorize the coupling circuit breaker closing without any comparison.

3.5.3 33 kV Cable Feeder Circuit Breaker(LFCB, RCCB)

The protection of this circuit shall consist of:

- F 50: Instantaneous over current protection
- F 51: Two stage Time delayed over current protection
- F50 N: Instantaneous earth fault protection (zero sequence)
- F51 N: Two stage Time delayed earth fault protection (zero sequence)
- 33 kV cables protection and fault localization

33 kV cables are protected at the AMS side by 33 kV circuit breakers and its associated protection relays. This means in case of a fault on 33 kV cables, it will be cleared by the circuit breaker, but the fault cannot be located and it will not be possible to segregate the faulty section.

The entire 33 kV Cables Network shall be protected by means of main protection as Line Differential protection with Pilot wires, which will automatically trip the 33 kV Circuit Breakers on either end of the faulty Section of the Cable. Line Differential protection with Pilot wires shall also be provided for the Section of 33 kV cables between ASS-RSS at the RSS. Differential relay shall be provided by the traction PST contractor . The space and CT core, wiring and cutout in the panel shall be provided by the RSS PST contractor . In addition, not limited to, back-up protection as Instantaneous and IDMT Overcurrent and Earth fault protection (50, 50N, 51, 51N) shall be provided, Over Current relay with as required, to ensure that the network is fully protected against any faults on the 33kV Ring Main Network. Therefore, the

functioning of these protections shall trip the either end of circuit breaker of 33kV power supply network

i) Auxiliary Transformer Circuit Breaker

(LVATCB) The protection of this circuit shall consist of:

- F 50: Instantaneous over current protection
- F 51: Two stage Time delayed over current protection
- F50 N: Instantaneous earth fault protection (zero sequence)
- F51 N: Two stage Time delayed earth fault protection (zero sequence)
- Temperature Alarm, first threshold
- Temperature tripping, second threshold
- Breaker failure protection (50BF) of LVATCB with LCB/CCB with provision of bypass rotary switch.

The thresholds shall be set according to the maximum of temperature the auxiliary transformer can withstand without damage.

ii) Zero Sequence Protections

A master earthing protection shall be provided through measurement of the zero-sequence current going through the earthing resistor of the 220/132/66 kV / 33 kV transformer. A current transformer installed on the earthing connection of the neutral, shall supply the current measuring relays of this protection, which shall be with adjustable threshold.

iii) Low Voltage Protection

The low voltage circuit breaker shall be equipped with microprocessor type relay-based protection to protect the main circuit against short-circuit, over-current and earth fault. This protection shall be equipped on the LVCB and LVCCB.

The selectivity shall take into account the time delay and the current level of the downstream protections. It should have adjustable current and time settings as per capacity of dry type transformers.

3.6 TRACTION PROTECTIONS

The purpose of the protections installed in traction feeder stations is to isolate all or part of the dependent equipment from the network, in case of phase-to-phase or phase-to-earth / rail fault.

Traction feeder stations are fitted with 25 kV circuit breakers for ensuring the isolation of the faulty sections.

The Traction Protection system can be broadly divided into two main groups:

- Traction set protection, which will essentially include all equipment starting from the
- HV busbar to which the Traction Transformers are connected, up to the 25kV bus bars from which the 25kV Traction Feeders take off.
- 25 kV Traction Feeder Protection, including OHE protection

3.6.1 Traction Set Protection

The protection relays required for protection of Traction Feeders (Overcurrent, Distance) and for protection against 'Panto flash over' and 'Wrong phase coupling' shall be provided at RSS by the RSS PST contractor . In addition, the protection relays required for protection of Depot feeders (Line differential/Distance as applicable and Overcurrent) shall also be provided by the RSS PST contractor .

Each HV circuit-breaker located upstream the power transformer ensures the protection of:

- the bus bars for connection to transformers on the HV side.
- the transformer,
- the 25 kV bus bars located downstream,

These protections include:

- Phase-phase and homo-polar over-current protections on the HV side (fn 50-51 and fn 50N-51N).
- the differential current protection of power transformers (fn 87),
- the over-current protection located on the secondary winding side of the transformer(fn 50-51),
- the REF protection installed on the main transformer (fn64R),REF protection
- The Buchholz relay, installed on main tank and tap changer tank, as well (fn 80),
- the temperature relay (fn 49) including:
 - oil temperature,
 - winding temperature.

3.6.2 Directional Power Protection

The function of directional protection (fn32) is to check the power transit direction in the catenary system, mainly due to regenerative braking, which could flow back to the HV grid through the transformers. Two stages are involved:

- a slow one,
- a quick one.

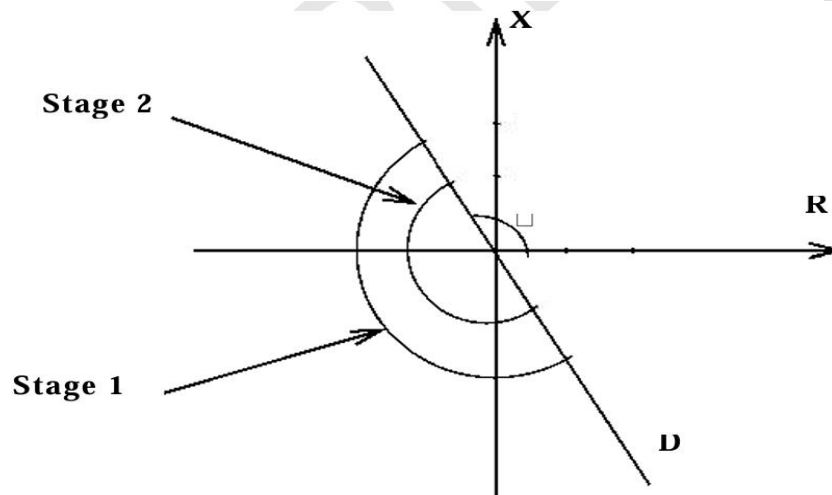
When the first stage is activated, a signal is emitted and a time-out 1 is started. When time-out 1 ends, a second signal is emitted. If, after 3 minutes, the fault still persists, a tripping command is sent to the concerned traction set circuit-breaker. When the second stage is activated, at the end of time-out 2, a tripping command and signal are emitted by the protection device; the 1st stage and 2nd stage current thresholds can be parameterized as well as time-outs, and angle of straight line D can be adjusted.

3.6.3 25 kV Incomer Feeder The protection shall consist of:

- F 50: Instantaneous over current protection
- F 51: Time delayed over current protection

- VDOC with DMT Protection
- Under voltage tripping to be provided from Line PT with time delay
- Breaker failure Protection (50BF) for TTCB with provision of bypass rotary switch.

3.6.4 Track Feeder Functional Description



From a feeder station, and for the same direction, each track is fed and protected through an assigned circuit breaker. Each portion of OHE fed by a circuit breaker is called "sector". Each sector is sub-sectioned into elementary sections (catenary section between two breaking apparatus). The sectors of same direction are put in parallel at the level of the paralleling station through interrupters.

All the faults on:

- the catenary network, together with the switchgear directly connected thereto,
- the rolling stock (upstream the circuit breakers),
- the paralleling stations (busbars, switchgear),

are detected and protected by the circuit breakers of the feeder station according to the following sequence:

- a fault is detected by the two protection devices (minimum Z or Over current) of the same direction through the paralleling,
- the related two circuit breakers are switched off,
- the fault localization system is put into service (operation is described later),
- the paralleling interrupters open due to the lack of power on the two tracks after a time period of about 500 ms,
- The re-closing order is given to circuit breaker within about 7 seconds,

If the fault remains (10% of the cases):

- the circuit breaker of the faulty sector trips and this is blocked open for 3 min,
- the fault locator determines the faulty elementary section
- the circuit breaker for the healthy sector switches on.

If the fault is transient (90% of the cases):

- the 2 circuits breakers re-close, the paralleling interrupters close following the
- energizing of the two sectors, after a time period of approximately 1 min.

1) Track Feeder Protection

Each track feeder circuit-breaker is actuated by:

- Minimum impedance protection,(fn 21) to be provided from Bus PT only
- Fuse failure monitoring for distance protection
- Over current protection (fn 50-51).
- **VDOC with DMT protection**
- Emergency/Backup over current protection
- Auto re-closure with provision of bypass rotary switch, Wrong Phase coupling
- Pantograph Flashover Protection with provision of bypass rotary switch.
- Master trip relay and AC/ DC U/V tripping
- **Delta I (current) protection (di/dt)**
- **Breaker Failure protection (50BF) of feeder breaker with 25 kV Incomers with provision of bypass rotary switch.**

In case of 25 kV supply is being feed to Underground section, Differential Current Protection for track feeder CB's shall also be provided at RSS in addition to distance protection of same feeder. Differential Relay shall be provided by Traction PST contractor but all other necessary provisions, space, separate CT cores, wiring, Cutout etc. to be provided by the RSS PST contractor . Distance Relay at RSS for this feeder shall be provided by RSS PST contractor .

3) Over Current Protection

An over-current protection is designed to detect faults occurring very close to the feeder station. This protection causes the tripping of the circuit breaker when the current reaches a value exceeding the highest load on the network.

Two stages of operation are foreseen:

- an instant one,
- a time-delayed one.

The tripping curves can be of two types:

- constant over time,
- if necessary, dependent over time, following an inverse, highly inverse or extremely inverse characteristic.

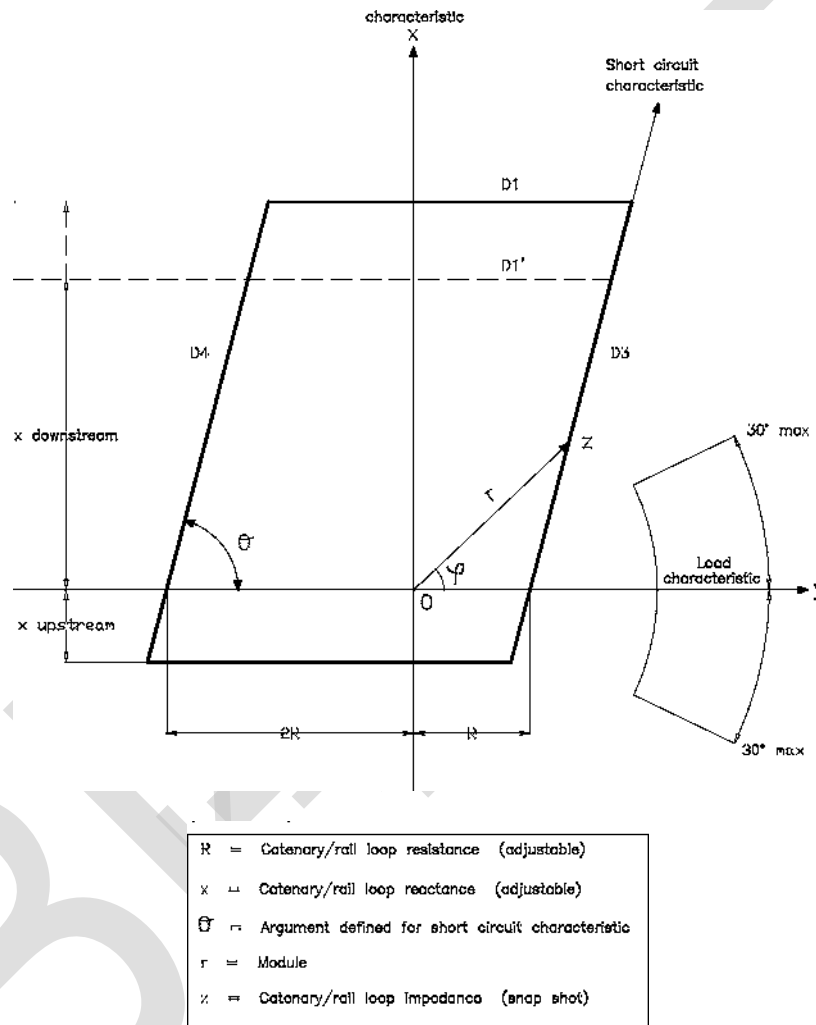
It should be noted that protections with thermal images, which are widely used in distribution networks, are not suitable for a 50 Hz catenary system.

2) Minimum Impedance Protection

This module is a single-phase impedance measuring (in R-X co-ordinates) relay, which operates when the impedance value falls below a selected adjustment threshold.

The minimum impedance module defines the quadrilateral characteristic by fixing the straight lines D1, D2, D3 and D4.

The possibilities of adjusting the various elements of the parallelogram enable it to be adapted to various network conditions. This protection is directional and selective; it makes a distinction between a high load and a distant fault of small intensity.



The minimum impedance protection is self-supervised and an internal fault in the protection entails the tripping of the associated circuit-breaker.

4) Selectivity of Protections

Selectivity calculation is based on the second-stage time-outs of over-current protections. As a rule, for a 25 kV fault, it is admitted that the time-out must be minimum but not nil to avoid tripping on a transient current or a load transfer.

Therefore, HV protections are calculated with a longer timing, which remains below the power

supplier line protection set values.

5) Other Protections

These protections are mainly concerned with the monitoring of the state and operation of:

- SF6 gas pressures of HV and 25 kV circuit breakers if any,
- Transformer temperature (oil),
- non availability of auxiliary supply (DC)

Two stages are involved:

- the first one is an alarm,
- the second one causes tripping (except for the SF6 gas pressure which entails blocking) of the equipment concerned.

6) Protection Back Up

Protections have a direct action on the tripping gear of circuit breakers and inform the local RSS automation protection system.

In case a protection is inoperative, a tripping order is sent to the higher-level circuit breaker via the local supervision after time delay (except for the power supplier HV circuit breakers). For 25 kV system, 50BF function shall be provided for the following cases:-

- 25 kV feeder CB to 25 kV Incomer CB
- 25 kV Incomer CB to TTCB

7) Fault Locator

This function is activated following a circuit breaker tripping due to:

- Minimum impedance detection,
- Over current,
- allowing an auto re-closure sequence.

The fault locator measures the centenary/ rail loop fault impedance and compare with the minimum impedance relay and determine the kilometer point from the feeder station. The fault parameters such as voltage, current, reactance & impedance should be communicated in SCADA.

3.7 RELAYS

General

All relays shall conform to the requirements of IS-3231/IEC-60255/IEC-61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear.

All the instantaneous relays should be capable of operating the circuit breaker within a duration of 70-110 ms from the occurrence of the fault. This time duration should include the dead time of the relays (20-30ms), MTR (10-20ms) & Circuit breaker (40-60ms) and this feature should be demonstrated during testing of the relays.

3.7.1 Numerical Relays

All main protective relays shall be of fully numerical type and shall comply as per IEC 61850 standard. Further, the test levels of EMI as indicated in IEC-61850 shall be applicable to these. All the relays shall be directly connected to the inter bay bus using Electrical/fiber optic cables and shall support peer to peer communication. The relays shall generate GOOSE messages as per IEC 61850 standards for interlocking and also to ensure interoperability with third party relays. Each relay should also generate an ICD file in XML format for engineering/ integration to a vendor independent SCADA system. All the relays shall have suitable rear and front ports for connectivity to SAS and PC/LAPTOP

3.7.2 Draw-out / Plug-in Type

All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in PST contractor 's scope of supply.

3.7.3 Operating Voltage / Current

All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

3.7.4 Auxiliary Relays / Contacts

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

3.7.5 Reset

All protective relays, auxiliary relays, timers, lock out relays (MTR) and interlocking relays specified shall be provided with self-reset type contacts /SCADA type as well as with externally hand reset positive action operation indicators with inscription type. All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operating indicators (Flag relays) for this purpose.

Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholz relays, oil and winding temperature protection, sudden pressure devices, fire protection etc.

3.7.6 Timers

Timers shall be of solid-state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

3.7.7 De-energization of Control Relay

No control relay which shall trip the power circuit breaker when the relay is de-energized shall be employed in the circuits.

3.7.8 Isolation of Trip Circuit for Testing

Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

3.7.9 Shunt / Series Relays

Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

- The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
- Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.
- Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.
- Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, etc.), and the alarm output signals.
- Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).
- For the current seal-in method, the seal-in shall be maintained until the circuit breaker opens at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the sealing shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.
- Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping.
- Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

3.7.10 Spare Pair of Contacts

All protective relays and alarm relays shall be provided with 10% extra isolated pair of contacts wired to terminals exclusively for future use.

3.7.11 Setting Range

The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

3.7.12 List of Installations using the types of Relays

The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

3.7.13 Phase Indications

All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue.

3.7.14 Scope of Numerical Relays

For numerical relays, the scope shall include the following:

- Necessary software and hardware to up /download the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.
- The relay shall have suitable communication facility for connectivity to SCADA. The relay shall be capable of supporting IEC 61850 communication standard.
- It is required to have Password Protection in relays for making any necessary changes in relay setting / configuration. It shall be possible to set a minimum 6-bit password in the relay from relay HMI/DR PC/Laptop. No password shall be required to view the settings / configuration in the relays.
- Accuracy Class of Current measurement in relays should be clearly defined. It should be for a minimum of 1% of the rated value.
- All IEDs shall have flexibility to add BI/BOs and have provision of 10 % of spare BI/BOs after final testing.
- All settings of relay must be readable from HMI of relays.

3.7.15 Communication Ports

The relays should have communication ports for local communication for relay settings, modifications, extraction and analysis of fault/event/ disturbance records from a laptop and for communication with substation automation system.

3.7.16 Facilities for Fault Diagnosis

The relays shall have the following tools for fault diagnostics

- **Fault record** – The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.
- **Event record** – The relay shall have the facility to store time stamped event records with 1ms resolution.
- **Disturbance records** – At least 5 sec of disturbance records shall be provided in the offered Numerical relays. Each record shall store data from at least 5 analogue channels and 16 digital channels. The data from DR function shall be available in IEEE/COMTRADE format and shall be compatible with the relay test kit being supplied

under this contract .CB opening status and MTR operating status shall be assigned in Disturbance Recorder of all relays.

- At least 250 events and minimum 8 Oscillo graphic record in RSS relays with minimum sampling rate i.e. 16 sample/cycle must be provided for investigation of all suspicious tripping and also provide provision for all disturbance record in DRPC. For ASS, minimum 5 Oscillo graphic disturbance records should be provided. The final Project of DRPC / Engineering PC (for bay controller) shall be handed over to Employer after commissioning.

3.8 RELAY AND PROTECTION PANELS

This section details the specification requirements for Relay and Protection panels for the receiving substation. The panels shall be used for housing the control and protection equipment for 220/132/66 kV and 25 kV system. The 33 kV control and protection system shall be housed in the local control cubicle of the 33 kV Switchgear. All type of protection shall be divided in group –A & Group-B and tripping at all voltage level shall be routed through respective MTR.

3.8.1 Constructional Features

- Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels & either front or rear for relay panels. All relay and control panels shall be provided with double door arrangement i.e one inner panel door and one glass front door with full height toughened glass. In case of panel having width more than 900mm, double leaf-doors shall be provided. Doors shall have handles with either built-in locking facility or will be provided with pad-lock.
- Relay panels shall be of simplex type design as indicated. It is the responsibility of the PST contractor to ensure that the equipment specified, and such unspecified complementary equipment required for completeness of the protective/control schemes is properly accommodated in the panels without congestion and if necessary, provide panels with larger dimensions. No price increase at a later date on this account shall be allowed.
- Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-42. Type test report for the ingress protection shall be submitted at the time of vendor approval. The PST contractor shall provide methodology for testing of Ingress protection of the CRP panel after commissioning at site, same shall be verified during testing stage. Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.
- All doors, removable covers and panels shall be gasketed all around with neoprene gaskets. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh. Cleaning schedule for the same shall be provided in the maintenance manual.
- Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.
- Panels shall have base frame with smooth bearing surface, which shall be fixed on the

embedded foundation channels/insert plates. Anti-vibration strips made of shock absorbing materials which shall be supplied by the PST contractor , shall be placed between panel & base frame.

- Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.
- Relay panels of modern modular construction would also be acceptable.

3.8.2 Mounting

- All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. No equipment shall be mounted on the doors.
- Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.
- The PST contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.
- The centre lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be not less than 450mm from the bottom of the panel.
- The centre lines of switches, Protection bypass switch, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.
- No equipment shall be mounted on the doors.

3.8.3 Panel Internal Wiring

- a) Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally
- b) All wiring shall be carried out with 1100V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used or internal wiring shall be as follows:
 - All circuits except current transformer circuits and voltage transfer circuits meant for energy metering - one 1.5mm sq. per lead.
 - All current transformer circuits one 2.5 sq.mm/lead.
 - Voltage transformer circuit (for energy meters): Two 2.5 sq.mm/lead.

- c) All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.
- d) Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.
- e) Wire termination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.
- f) Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the interconnecting wires.
- g) PST contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment
- h) **All relay panels should have 2 DC supply (from DCDB-1 & DCDB-2) and static changeover switch with O-ring diode shall be provided.**

3.8.4 Terminal Blocks

- a) All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 1100 V grade and have 10 Amps. continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.
- b) Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.
- c) At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. Unless otherwise specified, terminal blocks shall be

suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two of 2.5mm Sq. copper.
 - AC/DC Power Supply Circuits: One of 6mm Sq. Aluminum.
 - All other circuits: minimum of one of 2.5mm Sq. Copper.
- d) There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm.
- e) Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of
- f) internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the Employer's external cable connections if any. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.
- g) The number and sizes of the Employer's multi core incoming external cables if any, will be furnished to the PST contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included the scope of supply.
- h) There shall be provision of Test block in front of C&R panel so that the testing of protection relays and energy meter can be carried out without opening of panel door.

3.8.5 Painting

- a) All sheet steel work shall be phosphated in accordance with the IS:6005 "Code of practice for phosphating iron and steel".
- b) Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.
- c) Rust and scale shall be removed by pickling with dilute acid followed by washing with running water rinsing with a slightly alkaline hot water and drying.
- d) After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.
- e) The phosphate coating shall be sealed with application of two coats of ready mixed, stoved type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

- f) After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting. The exterior colour of paint shall be of a slightly different shade to enable inspection of the painting.
- g) A small quantity of finished paint shall be supplied for minor touching up required at site after installation of the panels.
- h) In case the bidder proposes to follow any other established painting procedure like electrostatic painting, the procedure shall be submitted for BSTP's review and approval.

3.8.6 Name Plates and Markings

- a) All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.
- b) All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.
- c) All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.
- d) Name Plates shall be made of non-rusting metal or 3 ply lamicaid. Name plates shall be black with white engraving lettering.
- e) All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

3.8.7 Miscellaneous Accessories

- a) **7 Plug Point:** 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
- b) **Interior Lighting:** Each panel shall be provided with a fluorescent lighting fixture rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

- c) **Switches and Fuses:** Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breakers (MCB). Selection of the main and sub-circuit MCB rating shall be such as to ensure selective clearance of sub-circuit
- d) **faults. MCBs shall confirm to IS: 13947.** Each MCB shall be provided with one potential free contact and the same shall be wired for annunciation purpose. However voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. Fuse carrier base as well as MCBs shall have imprints of the fuse 'rating' and 'voltage'.
- e) **Space Heater:** Each panel shall be provided with a space heater rated for 240V, single phase, 50 Hz Ac supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

3.8.8 Panel Earthing

- All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers.
- The material and the sizes of the bus bar shall be at least 25 X 6 sq. mm perforated copper or 50x6 mm GI strip with threaded holes at a gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing.
- When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of PST contractor . Provision shall be made for extending the earth bus bars to future adjoining panels on either side.
- Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of PST contractor .
- All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.
- Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel.
- VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
- An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 Mega Ohm resistor.

3.8.9 Testing

All protection schemes /logics etc. shall be tested from Primary side using primary injection kit. Also all configurations, LED indication, Tripping time, relay times shall be tested at site as per scheme. The detailed testing procedure shall be developed in consultation with the Employer and shall be tested jointly with BSTP.

3.9 SUBSTATION AUTOMATION SYSTEM

General

The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned similar substation automation system which must be in satisfactory operation on 220/220/66 kV system or higher.

The Substation Automation System (SAS) shall be installed at the BSRP receiving substations (220/220/66 kV) to control and monitor all the sub-station equipment from remote control center (RCC) as well as from local control center.

The SAS shall contain the following main functional parts:

- Bay Protection Intelligent Electronic device (IEDs) for Protection
- Bay Control Intelligence Electronic Devices (IED s) for control and monitoring conforming to IEC 61850 standards.
- Dedicated Bay Control Units and Bay Protection Units (BPU) shall be provided for each bay for Control and protection functionality on IEC 61850 standard. The Bay Control and Protection IEDs shall communicate on the IEC 61850 standard for Communication Networks and shall comply to the IEC 61850-5 for communication data modeling, IEC 61850-6 for Sub-station Configuration, Description Language for communication and IEC 61850-7-1 to 7-4 for Data Model and Services.
- Station Human Machine Interface (HMI)
- Redundant Gateway for remote control and monitoring via industrial grade hardware (to OCC and Backup Control Centre). The gateway should be able to communicate with OCC protocol. Each gateway shall have two communication ports for simultaneously reporting to two masters. The SAS system shall be connected to two control centers on a fiber optic network using two separate channels and will not be multi-dropped with other RTUs. The gateway shall have one spare port for connecting to a third master if required in future. The specific protocol to be implemented shall be advised to the successful bidder. It will be the bidder's responsibility to integrate his offered system with existing OCC system for exchange of desired data.
- Peripheral equipment like printers, display units, key boards, Mouse etc.
- Each of the IED/BCU/BPU shall be provided with its similar type of backup IED/BCU/BPU to ensure redundancy. This means for each IED/BCU/BPU the second hot standby IED/BCU/BPU should be provided which should automatically take over the system in the event of failure of main **IED/BCU/BPU. This shall also include the IED/BCU/BPU of PSA end.**
- **The main & standby IED/BPU should work HOT-HOT mode always.**
- It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory

control and data acquisition (SCADA) functions.

- It shall include industrial communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure on IEC 61850.
- The communication gateway shall facilitate the information flow with remote control centers. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

Layout details of Automation Equipment has been considered to be as follows:

Bay level intelligent electronic devices (IED) for protection and control shall be provided in the Control Room. Each IED will be directly connected to the Work station PC of the Station Automation System through a dual managed Ethernet LAN on fiber optic medium and shall communicate as per the IEC 61850 standard. The SAS shall be equipped with Gateway for remote communication as detailed elsewhere in the specification.

3.9.1 System Design

3.9.1.1 General System Design

- The Substation Automation System (SAS) shall be suitable for operation and monitoring of the Bay level intelligent electronic devices (IED) for protection and control and shall be provided in the Control Room.
- Each IED will be directly connected to the Workstation PC of the Station Automation System through a dual managed Ethernet LAN on fiber optic medium and shall communicate as per the IEC61850 standard.
- The SAS shall be equipped with Gateway for remote communication as detailed elsewhere in the specification.
- The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete BSBRP receiving substation including future extensions.
- The systems shall be of the state-of-the art based on IEC61850 for operation under electrical conditions present in high-voltage sub-stations and follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.
- **The offered SAS shall support remote control and monitoring from Operation Control centers (OCC) via gateways.**
- **In case of communication failure from OCC, control should be transferred to RSS automatically. Provision of forced transfer shall also be provided.**
- The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive so that operating personnel shall be able to operate the system easily after having received some basic training.
- The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.
- Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and

communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

- **License for SAS must have a provision for future expansion i.e spare points must be available for addition of at least 20% of existing bays.**
- **Software license should be independent of hardware. If hardware changes owing to ageing effect / failure, same software license should be usable. Software's shall be upgradeable to latest operating system any update / patch required for the same shall be supplied free of cost during the design life of the SAS system. I/O modules in IED must be provided to cater the signals + spare requirement of the respective bays.**

Ethernet Topology

The Ethernet communication infrastructure to 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 the topology.

Ethernet Switches

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. External switches are preferred 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.

3.9.1.2 System Architecture

- The system architecture shall be based on completely distributed approach also concerning the connection of any device to the system. Meaning any device, protection as well as control and station level devices shall directly be connected to the Ethernet backbone.
- The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.
- Functions shall be decentralized, object-oriented and located as close as possible to the process.
- The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.
- At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers. **Separate BCU to be provided for controlling of 25 kV Bus Coupler CB.**
- Each bay control IED shall be independent from each other, and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.
- The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fiber-optic cables, thereby guaranteeing disturbance free communication. The fiber optic cables shall be run in G.I conduit pipes. Data exchange is to be realized using IEC 61850 Communication standard with a redundant managed switched Ethernet communication

infrastructure

- All the numerical IEDs must be fully IEC 61850 compliant and must have the following features.
 - (i) Have peer-to-peer communication using GOOSE messages (IEC 61850) for interlocking.
 - (ii) Should be interoperable with third party IEC 61850 compliant devices
 - (iii) Should generate XML file for integration/engineering with vendor independent SCADA systems.
 - (iv) Should be directly connected to the inter bay bus on IEC 61850 without the use of any gateways. Connections of bay protection IEDs to the IEC 61850 bus through the bay control units is not acceptable.
- The communication shall be made in 1+1 mode, excluding the links between individual bay IEDs to switch, such that failure of one set of fiber shall not affect the normal operation of the SAS. However it shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.
- At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.
- Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. OCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.
- The station level contains the station-oriented functions, which cannot be realized at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centers.
- The GPS time synchronizing signal as per IEC61850 standard SNTP (Simple network time protocol) for the synchronization of the entire system shall be provided.
- **Drawings related to network architectural diagram with Proper marking and ferruling of switches/firewall/LIU/FO cables/Ports shall be submitted for approval.**
- **Details of switches/firewall/LIU etc. shall be submitted for approval.**

3.9.1.3 Functional Requirements

The high-voltage apparatus within the station shall be possible to be operated from different places:

- > Operation Control Centers (OCC)
- > Station HMI.
- > Local Bay controller IED (in the bays)
- > Apparatus Level

Operation shall be possible by only one operator at a time. The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, etc.

a) Select-Before-Execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

b) Self-Supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

c) User Configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely. It shall also be possible to interconnect and derive input and output signals, logic functions, using built-in functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

- a) Bay (a bay comprises of one circuit breaker and associated disconnectors, earth switches and instrument transformer) Level Functions*
- b) System Level Functions*

3.9.2 Bay Level**3.9.2.1 Bay Level Functions**

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- > Bay control functions including data collection functionality.
- > Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function, However BACKUP O/C Protection functions on Line and Transformer and on the Bus coupler can be integrated with the Bay control units on respective circuits.

3.9.2.2 Bay Control Functions**a) Overview**

- Control mode selection
- Select-before-execute principle
- Command supervision
- Interlocking and blocking
- Double command
- Synchro check, voltage selection
- Backup Protection function

- Run Time Command cancellation
- Transformer tap changer control (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor control and runtime supervision
- Operating pressure supervision
- Display of interlocking and blocking
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Integrated Graphical LCD HMI to display the Graphical Dynamic SLD, status information, alarms and disturbances with a display of 26 rows with 40 characters each in text mode 10x8(large)/20x15(small) symbols in graphical mode and with at least 4 levels of password protected access.
- Interface to the station HMI.
- Data storage for at least 200 events
- Extension possibilities with additional I/O's inside the unit or via fiber optic communication and process bus

NOTE: Integration of Backup Protection functions (Backup Over current Protection for Incomer feeder and Transformer, Over current protection on the Bus coupler) with the Bay control unit will be acceptable.

b) Control Mode Selection

> Bay level Operation

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

> Emergency Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

> Remote Mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

c) Synchronism and Energizing Check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- Settable voltage, phase angle, and frequency difference.
- Energizing for deadline - live bus, live line - dead bus or dead line dead bus with no

synchro-check function.

- Synchronizing between live line and live bus with synchro-check function

d) Voltage Selection

The voltages relevant for the synchro-check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the

circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

3.9.2.3 Bay Protection Functions

a) General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

b) Event and Disturbance Recording Function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. This shall give alarm if 70% memory is full. CB opening signal and MTR operating signal shall be assigned in Disturbance Recorder in all relays.

3.9.3 System Level

Functions a) Status

Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through one or more separate similar IED/BCU and all alarm and analogue values shall be monitored and recoded through this IED.

b) 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 values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

The measured values shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds. Threshold limit values shall be selectable for alarm indications.

c) Event and Alarm Handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and 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.

d) Station HMI

i) Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met; the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

ii) Presentation and Dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks or keyboard commands.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values
- Control dialogues with interlocking and blocking details. This control dialogue
- shall tell the operator whether the device operation is permitted or blocked.
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

iii) HMI Design Principles

Consistent design principles shall be adopted with the HMI concerning labels, colors, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colors for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state
- **Bus bar coloration to be provided as Red- Discharged, Green- Charged, Pink- No Communication, Yellow- Earthed and to be same in both main as well as standby server.**
- Dynamic overview of gateway along with status of gateway (Hot or Cold) should be available at operator terminal.

iv) Process Status Display 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 shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

There must be provision a provision of pop ups for critical signals for easy identification of operator. Pop up/ tag shall remain until acknowledgement of alarm.

v) System Supervision & Display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are

recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

vi) Event List

The event list shall contain events that are important for the control and monitoring of the substation. The event and associated time (with 1ms resolution) of its occurrence 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 for at least one month. The information shall be obtainable also from a 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
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value, or which shall be user defined for each measurand.
- 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 e.g. trips, protection operations etc.
- Alarm class

All the events shall be accessible to the operator all the time. In case of exhaustion of the system capability, deletion of events should occur in "First In, First Out" basis i.e. event which has been registered first in the system should be first one to be deleted.

vii) 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 table and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated. The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm

- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent). Filters for selection of a certain type or group of alarms shall be available as for events.

viii) Object picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- Type of blocking Authority
- Local / remote control
- ALDC/SAS control
- Errors etc.,

shall be displayed.

ix) Control Dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. It shall also be possible to use the keyboard for command activation. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- > Breaker and disconnecter

x) User-Authority Levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorization group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorization 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 login procedure. Only the system administrator shall be able to add/remove users and change access rights. The System ID from which operation is performed shall be logged in the event list.

e) Reports

The reports shall provide time-related follow-ups of measured 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 of selected analogue Values:

- Day (at 15 minutes interval)
- Week
- Month
- Year

It shall be possible to select displayed values from the database in the process display online. 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.

Following printouts shall essentially be available from the printer and shall be printed on demand (List is not exclusive):

- a) Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
- b) Weekly trend curves for real and derived analogue values.
- c) Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
- d) Provision shall be made for logging information about breaker status like number of operation with date and time indications.
- e) Equipment operation details shift wise and during 24 hours.
- f) Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
- g) Printout on adjustable time period as well as on demand system frequency and average frequency.
- h) Reports in specified formats which shall be handed over to successful bidder.

g) Trend Display (Historical Data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

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.

h) Automatic Disturbance File Transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

i) Disturbance Analysis

The PC-based workstation shall have necessary software to evaluate all the required information for proper fault analysis.

j) IED Parameter Setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

k) Automatic Sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.9.4 Gateway:

The gateway hardware shall be of latest technology and of industrial grade with RTU based technology, PC based gateways are not acceptable.

a) Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations. The Substation Automation System shall have communication ports as follows:-

- Two ports for simultaneous reporting to two masters, Operation Control Centre (OCC) - Yeshwantpur and BCC - Soladevanahalli/Akkupet depot at RSS. Both the ports shall work in HOT-HOT configuration necessary interface to ascertain compatibility with the SCADA system shall be done by the RSS PST contractor.

- One spare port for connecting to a third master if required in future

b) Communication Protocol

The communication protocol between IED's and station HMI shall be on the global Automation standard IEC 61850 at inter bay level and shall be on IEC 870-5-104 or existing compatible protocol for communication from local RSS to the OCC. SCADA Gateway to OCC at RSS shall be independent of the station LCC that is Substation SAS shall communicate with OCC even if the Local control centre fails.

3.9.5 System Hardware

The system hardware/software shall be of latest specification/technology at the time of commissioning and of industrial grade with minimum following: -

S. No		Hardware Specification
1	Make	HP/Dell/ Fujitsu/IBM/Advantech
2	Type	Rack Type, Industrial application for 24x7 working
3	Processor System	Intel Xeon Dual Core Processor 3.0 GHz or Quad Core 2 GHz or higher upgradeable to dual processing 4 cores. with Integrated disk controller, Integrated RAID controller
4	RAM:	8 GB upgradeable up to 16 GB
5	Hard Disk	Total storage of 2TB (2 nos. of 1 TB with RAID-1 hard disk controller or HDD Total storage of 3 x 500GB with RAID-5), SSD
Other accessories:		
6	Graphics	2x VGA
7	Monitor	32 inch (LED)

8	Optical Drive (DVD R/W)	16x DVD RW/(Multi burner Ultra bay Enhanced Drive)
9	Video Card	Standard Graphics controller
10	USB/VGA ports	4x USB Ports, 1VGA
		Hot swap Redundant Power Supplies & Hot swap Redundant Fans
11	LAN / Ethernet	2x Intel PRO/1000MT Dual Port (Teaming supported)
12	OS	Windows Server 2012 R2 SP0 64Bit or latest, at least b04 RDP license should be required for each machine. CAL/RDP license should be incorporated with OS license.
13	Antivirus	Antivirus With 3 Year Subscription McAfee/Norton/
14	Rating	90V-264 V AC (47-63 Hz)
15	EMI immunity	As per IEC 801
16	Support	Up to 10 year from commissioning for all hardware and software

The servers shall be housed in rack type panels and panel shall be supplied by OEM of servers. The panels have provision for proper ventilation / heat dissipation arrangement by providing fans controlled by thermostat and with suitable filters. Alarm/Status of healthiness of fan shall be taken on SCADA.

3.9.5.1 Station HMI, and Disturbance Recorder Work station:

The PST contractor shall provide station HMI. It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD.

a) HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user-friendly function keyboard and a cursor positioning device. The user interface shall be based on latest WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc .All unused USB / network ports to be sealed and blocked to prevent unauthorized access.

b) LED Visual Display Units- Not Used

c) *Printer*

It shall be robust & suitable for operation with a minimum of 220 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an offline mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All printers mounted in the control room shall be provided with a separate printer enclosure each. The enclosure shall be designed to permit full enclosure of the printers at a convenient level. Plexiglas windows shall be used to provide visual inspection of the printers and ease of reading. The printer enclosures shall be designed to protect the printers from accidental external contact & each should be removable from hinges at the back and shall be provided with lock at the front.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing. All printers shall be continuously online.

d) *Mass Storage Unit*

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit of CD-ROM / DVD-ROM with 4 GB or more capacity. The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with multi-Session capability. It should support ISO 9660, Rock Ridge and Joliet File systems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software.

e) *Switched Ethernet Communication Infrastructure:*

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. The bidder shall keep provision of 100% spare capacity for employer use. One switch shall be provided to connect all IEDs for two bays of BSBRP receiving Substation to communication infrastructure. Switches are not acceptable. The switches shall be equipped with fully integrated redundant power supply. It shall support priority tagging and SNMP for supervision. The switching time shall be as low as 5ms per switch. The switch shall be of industrial grade hardware with EMC to meet SA environment.

3.9.5.2 Bay Level Unit

The bay unit shall use industrial grade components. The bay level unit, 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 control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to

the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data required as per design of system reliability. The bay control unit shall be a fully compliant to IEC 61850 standard with icd file furnished for individual IED's in line with the IEC 61850 standards.

One no. Bay level unit shall be provided for supervision and control of each, 220/220/66kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. For 220/220/66 kV Incomer feeder circuits as well as Transformers circuits and Bus coupler circuits integration of O/C function within the bay control unit shall be acceptable. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The Bay level unit shall be a fully compliant to IEC 61850 terminal and also meet the all operational requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850 standards. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

3.9.6 Extendibility in Future

The Offered SAS shall be based on the latest global automation standard IEC 61850 which as part of it supports future seamless extension and integration of additional fully compliant IEC 61850 IED's of other suppliers.

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed/provided in such a manner that its extension shall be easily performed by the PST contractor /employer. During such event, normal operation of the existing substation shall be unaffected, and system shall not require a shutdown. The PST contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user.

These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future with IEDs of same manufacture/ different manufacture.

3.9.7 Software Structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary Hardwire firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an 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.

3.9.7.1 Station Level Software:

Human-Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SAS 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. Systems shall contain a library with standard functions and applications.

3.9.7.2 Bay Level Software:

a) System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The 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. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronizing with the remaining system without any manual interface. This shall be demonstrated by PST contractor during integrated system test.

b) 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 form part of a library. The application software within the control/protection devices shall be programmed in a functional block language.

c) Network Management System

The PST contractor shall provide Network Management System software for following management functions:

- Configuration Management
- Fault Management
- Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR workstation and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

- Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
- Maintain a graphical display of SAS connectivity and device status.
- Issue alarms when error conditions occur.
- Provide facility to add and delete addresses and links

The PST contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

3.9.8 Tests

The substation automation system (IEDs) offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV substation equipment installed in sheltered area in the outdoor switchyard an specified ambient conditions.

Type Tests :-

Control IEDs and Communication Equipment.

a) Power Input:

- Auxiliary Voltage, Current Circuits, Voltage Circuits, Indications

b) Accuracy Tests :

- Operational Measured Values, Currents, Voltages, Time resolution

c) Insulation Tests:

- Dielectric Tests, Impulse Voltage withstand Test

d) InfluencingQuantities

- Limits of operation, Permissible ripples, Interruption of input voltage

e) Electromagnetic Compatibility Test:

- 1 MHZ. Burst disturbance test, Electrostatic Discharge Test,
- Radiated Electromagnetic Field Disturbance Test
- Electrical Fast transient Disturbance Test
- Conducted Disturbances Tests induced by Radio Frequency Field
- Magnetic Field Test, Emission (Radio interference level) Test.
- Conducted Interference Test

f) Function Tests :

- Indication, Commands, Measured value Acquisition, Display Indications

g) Environmental tests

- Cold Temperature, Dry Heat Weather, Humidity (Damp heat Cycle)
- Vibration, Bump, Shock

3.9.8.1 Factory Acceptance Tests:

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 SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the PST contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. 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, as far as site conditions can be simulated in a test lab. If the FAT comprises only a certain portion of the system for practical reason, it has to be assured that this test

configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

3.9.8.2 Integrated Testing.

The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:

- Station HMI, DR workstation, switches along with all IEDs and printers.

All other switches for complete sub-station as detailed in section project shall be simulated as needed.

3.9.9 Power Supply

Power for the substation automation system shall be derived from substation 110V DC system. Online Inverter/s for each RSS of suitable capacity shall be provided for station HMI and its peripheral devices e.g. printer etc. Refer Annexure A4 for Inverter specifications. In the event of Power failure, necessary safeguard software shall be built for proper shutdown and restart.

3.9.10 Furniture

The SAS shall be supplied with the appropriate furniture to cater the SAS equipment including the storage, DESK and Chairs. The type and designs shall be approved by the Engineer to commensurate with at-least that provided in the existing BSTP RSS.

The space shall also be provided for placing of SCADA servers, RTUs, HMI etc. The provision of back up SCADA shall however be in scope of another bidder.

3.9.11 Training

Suitable training for operation and diagnosis of Substation Automation and networking system including installation / software backup etc. shall be provided to employer staff. The detailed training requirement shall be finalized in consultation with the employer.

4. CABLING

4.1 General

All cables including HV 220 kV, 33 kV, 25 kV and LV cables required for works in the RSS, except where otherwise stated specifically in this Tender Documents, shall be supplied and installed by the PST contractor.

EHV Cables from the KPTCL Substations/from existing 220 kV line to the RSS:

At GSS End: RSS PST contractor will supply 220/220/66 kV terminations, 220/220/66 kV LAs, structures, jumpers & connectors), erection of equipment, their foundations and structure and connecting this equipment with PSA equipment. The cable path and laying of EHV cables inside the RSS and GSS premises will be provided by the RSS PST contractor.

At RSS end: RSS PST contractor will provide suitable trench from entry point of cable in yard to RSS building and then suitable tray/path to GIS cable cellar/trench. GIS terminations and

its installation, Structures to hold the cable with termination in cable cellar/trench.

Copper cable support/clamp with suitable cushion may be provided in all cable support at RSS/AMS/TSS. At unavoidable locations where Copper cables are provided on angles, proper designed as per relevant IEC standard may be provided to prevent theft.

The exceptions are:

- 33 kV cables from the AMS to the designated ASS. Cable paths for these cables inside the AMS Room and in the yard, up to nearest ASS shall be in the scope of PST contractor.
- 25 kV cables from the outgoing 25 kV Switchgear to the 25 kV feeding post on the alignment shall be in the scope of PST contractor.
- Traction Return current cables between the running tracks and the RCMB in the RSS. Cable paths for these cables inside the RSS premises, up to the feeding post on the alignment shall be in the scope of PST contractor.

All cables including, 33 kV, 25 kV and LV, required for works inside and outside of the RSS shall be FRLS (Fire Retardant Low Smoke) Type.

All the indoor and outdoor cable trench openings to be sealed properly through EPDM Modular based Cable sealing system or equivalent. The modules should be "Low Smoke Index, Halogen free cross-linkable rubber compound based on EPDM (Ethylene-Propylene Diene Terpolymer)" or equivalent.

System provides foolproof protection against "Water, Dust, Humidity, Fire, Vibrations, Temperature Variations, Pull Tension Noise as well as Rodents to transit (in/out) cables/Pipes.

All cables penetrations of fire-rated walls or floors shall be sealed with a (multi-cable transit block) system for use in multi-cable transit frames.

- The multi-cable transit system should cover all cable diameters with a module adapter system where no peeling of single layers is necessary.
- The module adapters should be colour-coded adapter system like Red, Grey & Black for visual inspection to ensure that the cable transits are installed in full compliance.
- The inserting of the adapter module into the module and re-moving of the module adapters out of the module, respectively, should be reversible.
- For small to medium cables, single modules should be interlinked for easy installation. It should also be possible to separate the interlinked modules for individual use.
- Vendor needs to provide air blast loading test report with 42 bar pressure.
- System should have water tightness up to 11 Bar & Gas tightness up to 7 bar, ATEX approval and age testing certification.
- Frame/Sleeve SS material shall be AISI 316
- The Modular based Cable Sealing & Protection system conforming to IP65.
- Test Certificates shall be consider issued from International reputed agency like UL, FM. Also, should be seismic tested.
- Application shall be done by Accredited specialty PST contractor (HAFSC) and once execution done, complete report should be submitted using CFS DM software.

4.2 EHV 220/220/66 kV Cables

This specification defines the objectives, guidelines and requirements for Supply, laying, testing and commissioning of Extra High Voltage Cables 220kV from the Receiving Substations of Power Supply Authorities to the Receiving Substations of BSTP. There are 04 Receiving Substations of BSTP, which are taking Power from the sources mentioned below, at the voltages mentioned against each.

TABLE – I

No.	RSS Site	Feeder 1		Feeder 2	
		Source (KPTCL)	Approx. Length	Source (KPTCL)	Approx. Length
1	Mathikere	220kV Mathikere GSS	400 meters	220kV Peenya GSS	8 km approx..
2	Benniganahalli	220kV ITI GSS	5 km approx...	220kV HAL GSS	6 km approx....
3	Yelahanaka	220kV Puttenahalli GSS	1.2 km approx...	400/220kV Singanayakanahalli PGCIL GSS	6 km approx....
4	Soldevanahalli Depot RSS	220kV LILO from Neramangla to DB pura Line	4 km approx..	400KV PGCIL substation singanahalli	10 km approx
Note: The above-mentioned power sources and approx. length mentioned are indicative only. The final locations will be decided by employer upon approval of Power supply authority (KPTCL)					

The works to be executed under the Contract include Design as per KPTCL, Manufacture, transfer of technology, delivery, installation, testing, including integrated testing and commissioning, technical support, supervision of maintenance, training of Employer's staff and documentation for a complete System necessary to deliver the requirements of this Specification.

4.2.1 EHV CABLES**Detailed Description and Its Application**

This specification defines the objectives, guidelines and requirements for Supply, laying, testing and commissioning of High Voltage Cables 220 kV from the Grid Substations (GSS) of Power Supply Authorities (PSA) to the Receiving Substations (RSS) of BSBRP, or for use at any other locations as required.

The function of HV Cables is to provide a reliable and maintenance free link with a 100% standby for feeding power from GSS of PSA to RSS of BSBRP commensurate with the installed transformer capacity. The details of transformer installed capacities with overload capacities shall be furnished in tabular form depending at the time of necessity for communicating the approximate current cable capacity requirement to the PST contractor. The cable sizes shall also be worked out according to the rated capacity.

Power Supply characteristics shall be as per latest applicable Indian grid standards notified by Central Electricity Authority (CEA), India, as amended from time to time. The reference characteristics of the network are tabulated as under:

Rated voltage (rms)	220 kV	132 kV	66 kV
Maximum voltage (rms)	245 kV	145 kV	72.5 kV
Frequency	50 Hz	50 Hz	50 Hz
Neutral	Solidly earthed	Solidly earthed	Solidly earthed
Short circuit current	40 kA for 3 sec	31.5 kA for 3 sec	20 kA for 3 sec

Current rating for cables shall be determined taking into consideration the following installation methods as applicable:

- In the tunnels
- In cast –in pipes
- Trenches
- On brackets
- Ducts

And on the following as per design data:

- temperature correction
- thermal resistivity
- laying depth > cable distance
- cable grouping factor etc.

4.2.2 Governing Specifications

The details and specifications applicable to the 220/132/66 kV cables are as under:

4.2.3 220 kV Cables

The cables shall be of 220 kV, 1000 Sq.mm, single core–**aluminum** conductor. The cable shall be single core, stranded circular **aluminum** conductor, XLPE insulated, aluminium sheathed suited for rated fault current and short circuit power, outer covering HDPE sheath and overall graphite coated, conforming to IEC 60840. The conductor cross section shall be as specified in BOQ / Data sheet.

The EHV Cables shall satisfy the requirements given below and shall also comply with standards in force when the cables are manufactured, particularly which are in the following table. (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable):

S. No.	Specification No.	Title of Specification
1.	IEC-60840 latest	Power cables with extruded insulation and their accessories for rated voltage above 30 kV and up to 150 kV- Test Methods & requirements.

2.	IEC-62067 latest	Power Cables with extruded insulation and their accessories for rated voltages above 150kV.
3.	IEC -60228 - latest	Conductors for insulated cables.
4.	IEC-60502-2-latest Applicable clause only	Cross linked polyethylene insulated Thermoplastic sheathed cables.
7.	IEC-60230 latest.	Impulse test on cables & their accessories.
8.	IEC-60853-2 latest.	Calculation of the cyclic and emergency current rating of cables. Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages
7.	IEC-60811 latest.	Common test methods for insulating and sheathing material of electrical cables.
8.	IEC-60885- Part 3 latest.	Electrical test methods for electric cables. Part 3: Test methods for partial discharge measurements on lengths of extruded power cables

4.2.4 Abbreviations

- IEC – International Electro technical Council
- ASTM- American Society for Testing and Materials
- IS- Indian Standard
- TSS – Traction Sub Station
- ASS – Auxiliary Sub Station
- RSS – Receiving Sub Station
- OHE – Over Head Equipment
- XLPE – Cross Linked Polyethylene
- FRLS – Fire Retardant Low Smoke
- FRLSZH – Fire Retardant Low Smoke Zero Halogen
- FP – Feeding Post
- ACTM – AC Traction Manual
- SP- Sectioning Post
- SSP – Sub Sectioning and Paralleling Post
- SS – Sub Sectioning Station

Construction: All materials used in the manufacture of cable shall be new, unused and of finest quality. All materials should comply with the applicable provision of the tests of the specification. IS, IEC, Indian Electricity Rules, Indian Electricity Act and another applicable statutory provisions rules and regulations.

The various Constructional features required for the 220 kV EHV cables are as under:

i) Conductor

The Conductor shall be of Aluminum with a cross section as specified in BOQ / Data sheet. The construction shall be reverse concentric stranded Aluminum, compressed conductor. The Manufacturer shall indicate the following details:

- Number of wires
- Diameter of wires
- Quality of Aluminum
- Thickness and construction of sheath.

The conductor shall be formed from Aluminum conductor according to class 2 (compact circular stranded) complied with IEC 60228 latest publication. The maximum temperatures admissible for the conductor are as follow:

- Continuous service 90°C
- Overload condition 105°C
- Short Circuit condition 250°C

ii) Conductor Screen

A Conductor screen made of semiconducting compound shall be provided over the conductor, by extrusion. The extruded coat shall be continuous, with a constant mean depth, without bump, perfectly adhering to the insulation envelope. A semiconducting tape(s) shall be provided below the extruded semi-conducting conductor screen to prevent penetration of the compound into the underlying conductor. Minimum thickness of the conductor screen shall be 0.95 mm for 220 kV cables respectively. The electric resistivity of the conductor screen shall not be more than 5000 Ω cm at 20°C and not more than 25000 Ω cm at the working rated temperature.

iii) Insulation

The Insulation envelope shall be of cross-linked polyethylene (XLPE) insulation applied by extrusion.

Cable	Nominal thickness of insulation	As per IEC
220 kV	> 19 mm	60840

The voltage gradient in the rated working conditions shall be

- Equal to or less than 6 kV/mm at the level of internal semiconductor
- Equal to or less than 3 kV/mm at the level of external semiconductor

The mechanical characteristics shall be as follows:

In delivery condition

- > minimal traction resistance : 12.5 Mpa
- > minimal elongation before breaking : 200%

After ageing of 240 h at 135 °C

- > maximal variation of traction resistance : $\pm 25\%$
- > maximal variation of elongation before breaking : $\pm 25\%$

The isolating envelope shall comply with the hot condition elongation test:

- > temperature : $(200\pm3) ^\circ\text{C}$
- > on load duration : 15 minutes
- > mechanical constraint : 0.2 Mpa
- > maximal elongation on load : 100%
- > maximal elongation after cooling : 15%

The insulation compound shall be of high quality, heat, moisture, ozone and corona resistant. XLPE compound should be from reputed manufacturer e.g. Borealis Sweden or NUC Japan or equivalent with satisfactory service experience of more than 5 years. The Insulation shall be applied by triple extrusion and vulcanized using dry curing process to form a compact homogenous body free from micro voids and contaminants. The insulation shall be suitable for operation in wet or dry locations at conductor temperature not exceeding 90 deg. C for normal operation, and 250 deg. C for short circuit conditions.

iv) Insulation Screen

The Insulation screening shall be applied direct upon the insulation and shall be of a layer of extruded semi conducting thermosetting compound firmly and totally bonded to the insulation. Semi conducting compound should be from Borealis Sweden or NUC Japan or equivalent with satisfactory services.

Minimum thickness of Insulation screen should be 0.8 mm. The conductor screen, insulation & insulation screen shall be extruded in a single process. (Triple extrusion)

v) Water Swellable Tape

The tape shall be semi-conducting water swellable tape to be applied over the extruded insulation screening to block and prevent moisture propagation in a longitudinal direction. The semi-conducting tape shall be suitable for the operating temperature of the cable and compatible with the insulation.

vi) Metallic Sheath

Metallic sheath shall be Aluminum sheath. The metallic sheath shall be able to carry a short circuit current of **50kA** for 1 seconds.

In the case of metallic sheath of Corrugated Aluminum or Copper sheath the bidder shall submit the calculation of area of aluminum or copper sheath in this support.

vii) Bedding Tape

The bedding shall be anti-corrosive layer of Bitumen compound.

viii) Outer Sheath

The outer sheath shall be **extruded black HDPE complying to IEC-62067**. The outer sheath should have embossing at every one meter for PST contractor Name, manufacturer name, BSBRP, Voltage grade etc. The Mechanical Characteristics shall be as follow: In delivery condition

> minimal traction resistance	:	12.5 Mpa
> minimal elongation before breaking	:	300%

After ageing of 240 h at 110°C:-Traction Resistance

> minimum value	:	12.5MPa
> maximum variation	:	± 25%

Elongation before breaking:

> minimum value	:	200%
> maximum variation	:	± 25%

The variation is the difference between the medium value obtained after ageing and the medium value without ageing, expressed in percentage of the last.

4.2.5 Additional Requirement

The Employer may decide to visit the works of cable manufacturer to verify the manufacturing process mentioned.

The Bidder along with the bid shall submit the details regarding cable construction, bill of material and the manufacturing process proposed to be adopted for the manufacturing of cables to be used in the project, along with Quality control measures adopted by the Manufacturer, to ensure:

- > The values and tolerances are strictly as per IEC.
- > The cable manufacturer exercises strict quality control measures, including stage inspections, routine inspections etc. to ensure conformity to standards.

Periodical inspections of the Manufacturer works, manufacturing processes, Internal Quality control records of the manufacturer etc shall be carried out by the User (BSBRP/Nominated agency), to ensure compliance to Quality standards.

The client will deliver the supply, upon request, only after execution of in-plant inspection operations and satisfactory testing according to the technical requirements imposed.

- The cables shall pass all the tests stipulated in the IEC rules in force on the date of the order.
- The sleeves and the insulating materials used shall meet the guarantee requirements imposed.
- The equipment shall be capable of withstanding intensive use without alteration, and of

performing its duty even after extended idle period.

- Assembled Pulling eye shall have to be supplied with all cables.
- GI Steel drum with steel packing shall have to be supplied.
- Drum length of the cable shall be finalized after approval of Sheath Voltage calculations.

a) *Atmospheric and Climatic Conditions*

The entire equipment will be designed for operation in hot weather, according to the climatic conditions defined in General Specifications.

The equipment will be sturdy and properly treated against corrosion. This protection shall be suited to the various environmental conditions encountered in the various parts of the network.

It must be noted that environmental conditions will be very severe during construction; these conditions shall not be the cause of any alteration of equipment or material whether already installed or simply stored.

b) *Maintenance & Life*

The cable should be designed for maintenance free best service life best in the industry and not less than 30 yrs for all types of installation & under prescribed environmental conditions.

c) *Special Condition*

The manufacturer shall have laid down in-house selection process of the raw material used and shall submit all details, if equivalent raw material is used wherever specified.

d) *Testing*

The 66kV cable shall comply Test Standards as per IEC 62067, IEC 60840 (latest). The manufacturer shall not change the Bill of Material used in the manufacturing of samples used for routine testing and Type testing as repeated above intend to supply against the contract

e) *Data Sheet- EHV*

CABLES As per GTP

4.2.6 Cable Laying

4.2.6.1 General

The Cable Laying works shall be executed according to the rules of the Art pertaining to professional grade and generally in compliance with International Standards and Indian Standards.

- EHV/HV Power Cable laying shall be carried out by Cable supplier/Manufacturer
- The PST contractor shall conduct the GPR survey to identify the other utilities in the proposed route and submit at least 3 routes for laying of cable from PSA grid substation to BSBRP RSS with full details including underground utilities for approval of engineer. After finalization of cable route, the PST contractor shall submit the method statement for laying and jointing of cable for approval of engineer. The general guidelines for

preparation of Method Statement for cable laying is given in Annexure 15.

- The area shall be excavated only after getting necessary permissions from the concerned civic agencies and work shall be executed as per the approved method statements. The excavated area for laying of cable (irrespective of method of laying either by open trench method or trenchless piping or by any other method) is to be fully protected by means of barricades of 2.5m width and 2.0m height in continuous manner as per BSBRP SHE standards. Failure on account of not providing the barricade at the excavated site will attract the penalty as per various clause of SHE of contract.
- The excavated area will be filled up within period of one month from the date of excavation. The temporary restoration work by filling of excavated area with the earth and PCC over the excavated area shall be done by the PST contractor satisfaction to the engineer-in-charge and final restoration shall be done by the civic agencies. Penalty will be imposed at the rate of Rs. 5000/- per day if PST contractor fail to complete the above activities within time frame of one month.
- Ground penetration survey (GPR): The PST contractor shall carry out the GPR survey of the complete cable system and submit the drawing marking the coordinates showing distance, depth along the cable path. The survey should be carried out before starting the cable laying work to ascertain the utilities and after the completion of cable laying work so as to prepare "As Built Drawing".
- Foot patrolling of cable route (from PSA end to RSS) shall be carried out by the PST contractor till handing over of the system to the employer, any type of damage/defect shall be the sole responsibility of PST contractor .
- The PST contractor shall be liable to arrange all necessary tool and equipment like DG sets, portable road rollers etc. required for laying of cables without any additional cost to the Employer.
- Wherever appropriate the cables shall be laid in trefoil formation as per finalized design and shall be secured using nylon reinforced glass trefoil clams of appropriate design at regular interval.
- Drum length of the cable shall be finalized after approval of Sheath Voltage calculations

4.2.6.2 Cable Laying

The EHV Cables between the Power Supply Authorities Substation and the BSBRP RSS shall be laid in ground depending upon the site conditions of the selected route, any of the following paying conditions, may be adopted

- Case 1 – Direct buried, with the cables (3/6) of each circuit laid in trefoil formation and side by side in one trench.
- Case 2 – Laid in underground duct
- Case 3 – Laid in Trench less piping.
- **Case 4 – Push Pull Method**
- Case 5– Laid in abutment crossing/ Laid in Air, supported on piers/walls, for nallah-crossing
- **Case 6:-Laid on BSTP viaduct.**

a) Case 1:-Direct Buried Method

The laying conditions shall not be less than the following for Direct Buried Method:

- The trench for carrying the cables shall be at least 1.8m deep and 1.1m wide, which may vary as per site conditions with the approval of employer. Sufficient spacing (not less than 2D) should be maintained between two circuits as per standards.
- Each of the 2 feeders shall consist of 3/6 single-core cables, and laid in trefoil formation.
- Cables shall be laid at a depth of 1.7 m below the ground level and over a 100 mm bed of coarse sand.
- Trench is to be filled with sand upto a depth of 1100 mm below the ground level.
- Warning concrete slabs of at least 50 mm thickness shall be laid above the sand and on the both inner sides of trench.
- Trench shall then be filled with earth upto a depth of 300 mm below the ground level.
- A warning net shall then be laid above the earth filling (at 300 mm depth below the ground level). A warning tape shall also be laid appropriately with Bengaluru Metro Rail Corporation marked on it.
- The top space of 300 mm shall be suitably filled with compacted Boulder and Bitumen/Jelly and given a final finish matching the surroundings.
- The cables shall be tied through trefoil clamps after 5 meters each for keeping the cables intact in case of trefoil formation. At locations, where there is change of level of laying, the cables shall be tied through trefoil clamps after 2.5 meter each.
- Identification tapes in continuous length should be provided at every 10 m for identification of cable circuits during maintenance/repair.

b) Case 2:- Laid in Underground Duct

In specific locations, the Employer may require the cables to be laid in underground ducts. The underground ducts shall be laid where road construction or formation is

under construction or where water logging stretch is expected or as per the specific site condition. The underground duct may be provided with open cut & cover method with due permission of civic agency. In specific circumstances, where open cut & cover is not possible due to site constraints, Suitable safe method may be undertaken with proper safety norms only after approval of BSBRP.

c) Case 3:- Laid in trenchless piping

On all road crossings and at other specific locations, cable laying shall be through trenchless drilling and the cables shall be passed through suitable grade High Density Polyethylene (HDPE) of min. diameter equal to 1.5 times diameter of cable. The grade of HDPE pipe to be used depends upon the followings:

- Sub-soil properties and conditions
- Lengths of HDD shot
- Depth of HDD shot

PN-6, PE-80 grade HDPE pipes (as per IS: 4984) shall be used for span length of 70 to 80 meter and depth of shot is less than 5m.

d) Case 4:- Jack Push Pull Method

Jack and Push technology shall be used for trenchless crossing of all rail crossings and other specific locations:

- As per soil condition the excavated pit, shoring & shuttering is done to avoid collapse of soil in the pit. In case of sub soil dewatering is required to be done to maintain the minimum table water in the pit.
- Lowering of guide rail, pushing rig- On readiness of the thrust pit guide rails are lowered in the pit properly aligned for level and angle of push. Once aligned the pushing rig and set in position on the pushing pad/rig itself.
- Lowering of Main pipe- Once the pit is ready, the 1st segment of the pipe to be pushed is lowered in the pit along with the pushing rig depending upon the method to be adopted.
- Placement of pipe in position and alignment- The pipe is slowly pushed into the soil by extending rams of the hydraulic jacks. Once the pipe tip enters the mother earth the final line and level is checked again and any misalignment rectified.
- Pushing of the pipe- After the final alignment the pushing of the pipe starts by extending the rams of the hydraulic jacks. Excavation of the soil from inside the pipe is done on completion of each stroke of the ram, which varies from 200 mm to 700 mm depending on the soil condition and diameter of pipe.
- Closing of the ram and preparing for next stroke- On completion of each stroke the rams of the jacks are closed or taken back and made ready for the next stroke. Soil excavated from the pipe is removed. The ram of the jacks are gradually extended again to push the pipe segment further.
- Lowering of further segments, jointing and re-pushing- Once the pipe segment is inserted the pushing pad is withdrawn back towards. The thrust wall and new pipe segment is lowered, placed in position, aligned and seal jointed with the old pipe.
- All the process mentioned above repeated till the determined length of the pipe is pushed through the soil and the penetrating tip of the main pipe emerges out sufficiently at the receiving pit.
- Obtaining Final level- On arrival of the pipe at the receiving pit the final level of the pipe is checked and recorded.
- Restoration- Once the inspection and testing is done by the concerned authority, the site is restored after evacuating the pits. All pits are filled and leveled. All tool, tackle, machine and material is finally removed from site.

e) Case 5:-Laid in abutment crossing/ Laid in Air, supported on piers/walls for nallah-crossing

On all abutment crossing or in air, supported on piers/walls, for nallah crossing and at other specific locations, cable laying shall be on the galvanized steel structures which can withstand wind velocity of 160 kmph, supported on piers and have sufficient structural strength. The minimum average weight of zinc coating should be 1000g/m² (RDSO). The cables should be well protected by providing MS sheet of thickness 8mm at least fastened with nuts and bolts & tag welded on all sides to be protected from any

pilferages.

The arrangement shall render cable absolutely safe from any natural calamity. The cable shall not be exposed or get affected due to stray fire caused in the vicinity. All the bridge type structures carrying cables should be fully enclosed. The cable chamber should be filled with sand cushioning lockable manholes may be provided in top. **The entry of cables should be properly covered with concrete structure with inclined slopes deep into the ground.**

f) Case 6:-Laid on viaduct.

For cable laying on viaduct will be laid on cable brackets/ viaduct slab and supported on piers/walls for cable raise/ lower shall be on the galvanized steel structures which can withstand wind velocity of 160 Km/h. The minimum average weight of zinc coating should be 1000g/m² (RDSO). The cables should be well protected by providing GI sheet of thickness 8mm at least fastened with nuts and bolts & tag welded on all sides to be protected from any pilferages. The arrangement shall render cable absolutely safe from any natural calamity. The cable shall not be exposed or get affected due to stray fire caused in the vicinity.

4.2.5.3 Pipes for Pilot Wire / OFC Protection

In addition to HDPE pipes for power cables, one additional PN-6, PE-80 grade HDPE pipes, each for one circuit not less than 100 mm dia, shall be provided by RSS PST contractor throughout the entire cable route length (irrespective of method of laying) for pilot wire protection. HDPE pipes will also be provided by RSS PST contractor for other cables such as copper-core or optic fiber cables for control and monitoring, tele-communication etc. as indicated in the Interfacing Requirements, cables shall be supplied by other PST contractor s).

To achieve redundancy the double run of pilot wire cable shall be laid. The pilot wire cables shall also be laid at the same depth as of the power cables to avoid damages.

4.2.5.4 Cable Protection at Changeover Location

The cable path, when changing from buried in ground to underground duct or trenchless piping shall be adequately protected by proper sealing in concrete or other suitable means of sufficient mechanical strength to avoid cable from suffering damage due to heat/fire/water in-grass etc.

4.2.5.5 Pulling Chambers, if Required (in any Special Case)

Pulling chambers of size 4m long, 3m wide and at least 2.5m deep shall be provided, as necessary, along the route for pulling of cables. This pulling chamber shall be barricaded properly and filled with sand and soil after laying work completed. The temporary restoration with proper compacted and PCC shall be done by the PST contractor , however final restoration shall be done by civic agency.

4.2.5.6 Jointing Bays

Pre-casted RCC Jointing Bays shall be provided at the joint location of suitable size dully approved by engineer-in-charge.

4.2.5.7 Route Markers

The route shall be appropriately marked by suitable retro-reflective cable markers, at every 50m and at both ends of road crossings and positions of straight through joints shall be indicated by suitable boards.

4.2.5.8 General Precautions

Following Precautions in addition to that recommended by the cable Manufacturer to be taken while laying of cables applicable for all EHV cables (220/220/66 kV) and HV/MV Cables (33 & 25 kV) shall be taken during cable laying:-

- In case of direct burial the trench for carrying the cables shall be at least 1.8m deep and 1.1 m wide.
- In case of direct burial cables, the sand bedding for the cables should be installed smoothly and any object as gravel, stones, harmful chemical etc should be removed.
- Minimum Bending Radius of the cable shall be more than 20 D, where D is the diameter of the cable.
- On all road/rail crossings and at other specific locations, cable laying shall be through trenchless drilling and the cables shall be passed through High Density Polyethylene (HDPE) Pipes of appropriate diameter and thickness. The minimum diameter of HDPE pipe should be 1.5 times the diameter of cable. HDPE pipe should have sufficient strength to take care of forces under heavy traffic when laid under railways/ road crossings.
- The cable path, when changing from buried in ground to underground duct or trenchless piping shall be adequately protected by proper sealing in concrete or other suitable means of sufficient mechanical strength to avoid cable from suffering damage due to heat/fire/water ingress etc.
- A thermally stable backfill of sand (with proper compaction) is to be used to ensure a known thermal conductivity around the cable in order to maintain the cable rating.
- Cables are installed on a bed of sand by the use of winch or power rollers. Rollers should be placed at a distance of 3 to 4 meters; at bends special corner rollers should be placed so that the cable does not touch the side walls of the trench. This should ensure that no damage is done to the sheath.
- Cable shall be pulled by Winch and if necessary than manually however, Cable shall be pulled from one side only; no intimate pulling by tying in between shall be done. While pulling the cable both the pulling tension and side wall pressure should be kept less than the permissible limits. Permissible Values for Pulling tension:

$F_{max} = A.D_{max}$, where

A	=	Conductor cross sectional area
	=	Maximum permissible stress (N/mm ²)
	=	50 N/mm ² for single core copper conductor
	=	30 N/mm ² for single core Al conductor

Similarly, **the Sidewall Pressure (P) =**

T/R where,

T = Pulling tension at exit from bend;

P = Side wall pressure;

R = Bending Radius

Coefficient of Friction in Direct Burial Cables shall be = 0.1 to 0.2

However, if the route has several right angles bends then cable pushers could be used to reduce the tension and maintain it within the limits. This will give the necessary relief on the cable by removing some of the back tension on the cable. By pulling and pushing the cable at the same time there will be a very low level of tension on the cable.

- Cable drum shall be unloaded with a crane fit for purpose and shall have adequate capacity to lift the drum and install in the final position for installation. Drum should be mounted on the cable jack and should rotate freely; in case pulling stops overrunning of the drums should be prevented using drum brakes.
- When pulling cable mechanically by a pulling winch, the cabling winch rope is coupled to the cable by means of the pulling eye. Ensure that the winch has a pulling recorder and a tension meter. The pulling tension is transferred to the conductor.
- Pulling tension and sidewall pressure should not exceed the maximum permissible pulling tension. Maximum pulling speed of the cable shall be 7mtrs/min. pulling speed shall be reduced at corners.
- Graphite grease should be provided on the cable at the end of the ramp before the cable enters the trench.
- Manufacturer's representative (Engineer) shall be available at site during cable installation, testing and commissioning. He shall certify that the cable laying, testing and commissioning has been done as per Manufacturer's representative and warranty is intact.
- Proper coordination with Joints and termination suppliers shall be done. Jointing and termination shall be carried out by qualified jointers certified by manufacturer. The manufacturer shall certify that the process has been completed as per manufacturer's recommendations and warranty is intact.

4.2.7 Cable Accessories and Bonding

a) Straight Through Joints

The straight through Joints should be Pre-molded Type (for 220kV) and HEAT SHRINK type or cold shrink type (for 33 kV, 25 kV) of proven technology and make, suitable for underground buried cables. The joint should comprise of stress control sleeves, insulating sleeves and co-extruded dual wall Tubing comprising of an insulating and semi-conducting layer. A mechanical connector with shear head bolts shall make the conductor connection. The product should be type tested as per IEC specifications

b) General Specifications

- The product offered should be proven and should be in use in India for a minimum period of 5 years for the same voltage class. List of past supplies in India to be furnished. Performance certificates to be submitted along with the offer.
- The product offered should have long (30 years) shelf life. Details of shelf life of each component shall be submitted with vendor proposal.
- Offers should be supported with type test certificates (**not older than 05 years at the time of post bid vendor / make approval** from CPRI/CESI/KEMA or accredited test laboratories as per IEC/IEEE specifications, failing which the offers shall be rejected.

c) General Specifications for Joints and Terminations for 220/220/66 kV Cables

- The Terminations and Joints should be tested in accordance with both the IEEE 404 as well IEC 60840 / 62067. The PST contractor shall submit details of the material (items) used in cable joints along with vendor proposal.

- Joints and terminations should be done by an experienced jointer having proper competency for same under the supervision of Joint manufacturer.
- Ease of Installation: The joint body should be a three-piece assembly to allow for easy installation without the use of special tools and also to keep a firm control on the positioning of the stress control cone etc.
- The termination body should be a composite housing with molded silicone shaded profile for the external leakage insulation.
- The joint and termination should employ mechanical connectors for which the manufacturer must have a minimum of 10 years of experience in the design, manufacturing and usage.
- Jointing of EHV / HV cables shall be in sealed environment to prevent ingress of dust and moisture during jointing process. Care shall be taken in handling the joints during laying as well as during repairing of joints (if any) to avoid failure at later stage.

The Terminations and Straight Through Joints for 66kV cables shall be Heat Shrinkable type suitable for 66kV (E) Grade of higher, single core 800 sq. mm, 630 sq. mm or higher, XLPE Insulated, Aluminium or copper sheathed cable

d) For 220 kV:

The type of terminations for 220kV incoming cables may be Indoor OR Outdoor depending upon the equipment being provided at PSA end and in BSTP RSS.

Bonding

General

In High Voltage power transmission, three single core cables are used in place of three core cables. In the single core power transmission, the cables are usually covered with a metallic sheath to prevent ingress of moisture, protect the core from possible mechanical damage and create an earthed shield. Unlike the three core cables, the Single core cable behaves like a transformer. The current carrying conductor of the cable acts as the primary winding and the metallic sheath as the secondary. The field of the current carrying conductor induces a voltage in the metallic sheath of the cable. The calculation of sheath voltage shall be done as per IEEE 575 to limit the sheath voltage below 65 volt as per cable actually laid.

> Sheath Induced voltage:

The magnitude of the EMF induced in the cable sheath is directly proportional to the magnitude of the load current carried by the conductor, the mutual inductance between sheaths of the cables, the spacing between the cables and the cable length.

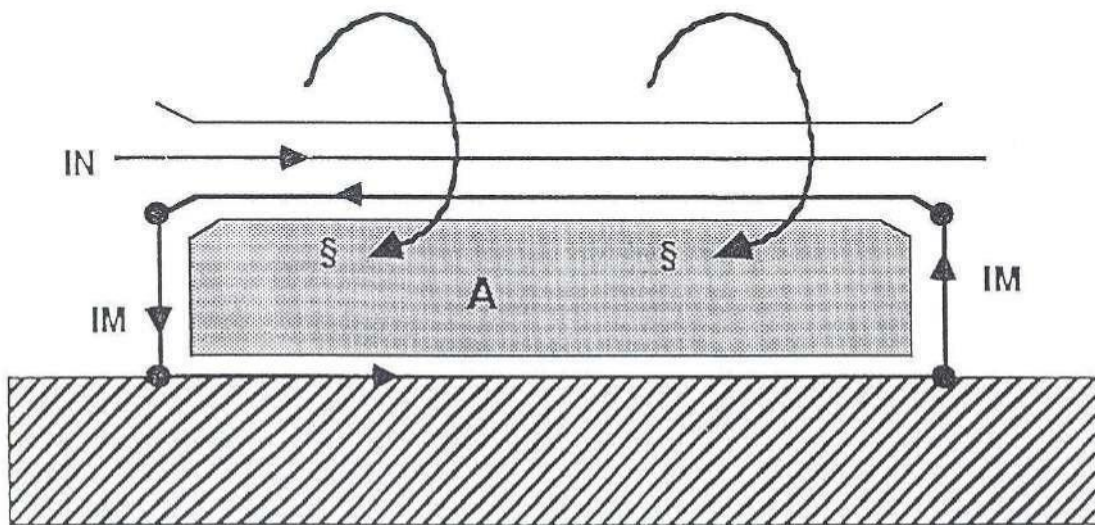
$$E_s = 314. I. L \text{ Volts/m}$$

$$E_s = \text{Sheath Voltage}$$

$$I = \text{Current in the conductor}$$

$$L = \text{Mutual inductance between the sheaths of cables}$$

This induced EMF causes a circulating current to flow in the sheath when both ends



of the metallic sheath are bonded to the ground.

Circulating Currents:

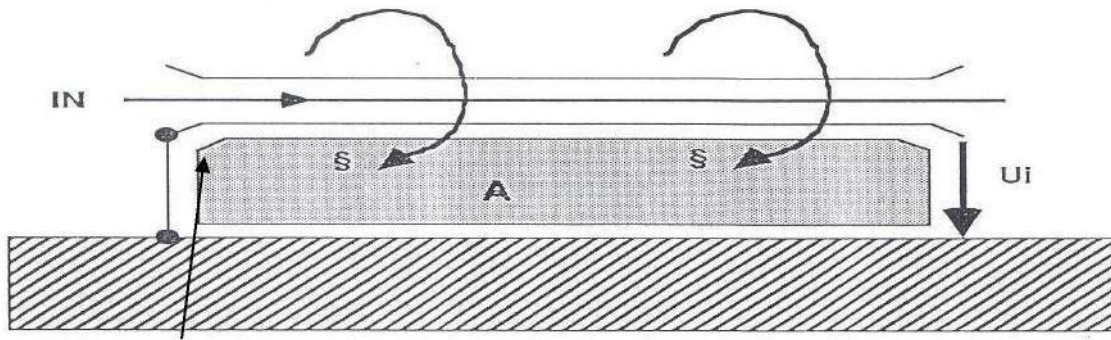
Circulating currents are generated in the metallic sheaths of 1/C cables when the cable's insulated conductor is carrying alternating current and its metallic sheath is bonded to ground at both ends. It doesn't matter what metal the layer is. If it's metal and grounded at both ends there will be a current induced into it. The magnitude of this circulating current depends on the current in the conductor and the impedance of the loop formed by this layer and the ground path. This sheath circulating current causes sheath-circulating losses and causes heating. In such cases, the cables must be de-rated to 70% of their normal conductor current. To utilize the full ampacity of the cable, special bonding methods are employed.

Sheath Bonding methods:

- Single Point Bonding
- Mid-Point Bonding
- Cross Bonding

Single Point Bonding:

In single point bonding, one end of the sheath is grounded and the other end is kept floating. Usually the supply end is grounded. Provision shall be made to provide



the Ground Continuity Conductor of adequate size to connect both the earthed ends.

When the cable's Armour / sheath / concentric ground is floating at one end, a standing voltage will be generated on this metallic layer. The magnitude of this standing voltage is directly proportional to conductor current and to cable length. It's also proportional to the spacing between cables and how they're laid out (i.e. flat or trefoil), but current and length are the big factors. Generally standing voltage is not of concern except if the runs are long and / or conductor current is high.

As per the earthing practices as laid down in IS 3043, this standing voltage should not exceed 65 Volts. Typically, Single point bonding is adopted for feeder lengths not exceeding 1 km.

During installation care must be taken to ensure that cable jackets are not damaged. If they are damaged the Armour or sheath could make contact with ground along the run. This forms ground loops, which would, allow circulating currents to flow and this causes cables to overheat. Sparking and cable failures have also been observed at points where cable jackets have been damaged and these circulating currents are allowed to flow to ground. The floating end should be insulated from the ground. A Sheath Voltage Limiter is installed at the floating end so as to ensure that sheath does not see very high voltages at the time of fault. If the sheath is damaged, moisture ingress & flow of circulating current shall happen.

Single point bonding shall be carried out with an insulated ground continuity conductor as per fault current capacity. For longer feeder lengths, multiple single point bonding shall be carried out with a ground continuity Conductor.

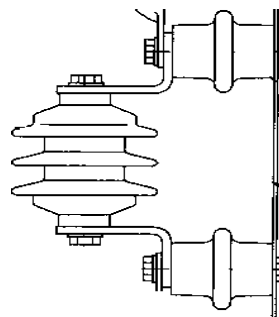


Fig. Multiple single point Bonding

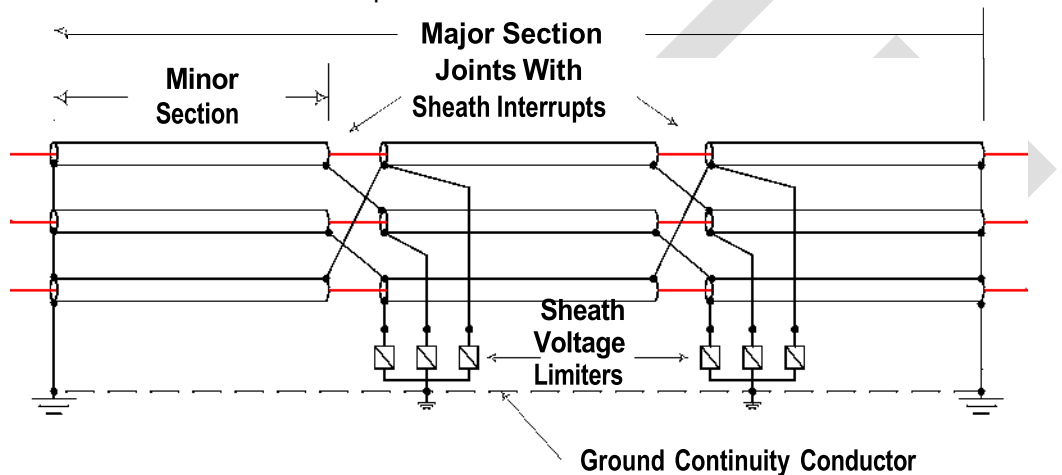
Mid-Point Bonding:

In this method, the bonding is carried out at the center of the cable feeder and the other two ends are grounded through SVL. This ensures that the sheath standing voltage is halved.

Cross-bonding:

For longer feeder lengths wherein, the Sheath induced voltages are high, cross bonding of sheaths is to be carried out. The sheaths are electrically transposed at every splice, reducing both currents and voltages. SVL's are needed at 2 out of 3 joint locations.

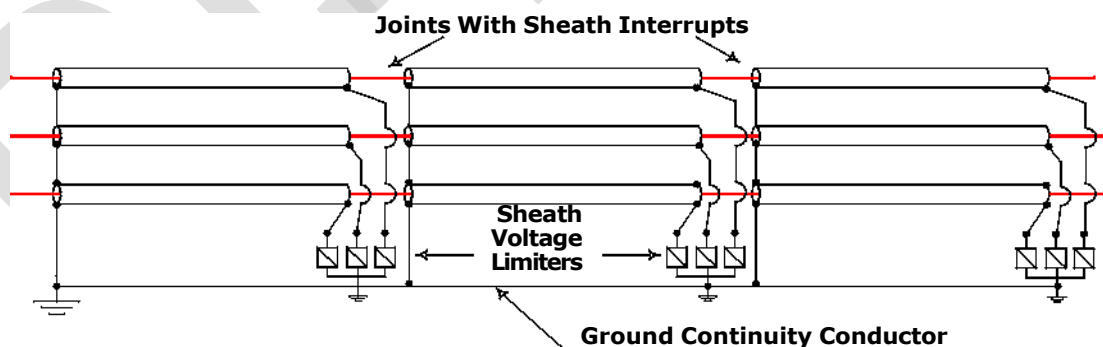
The sheath bonding Copper cables (3.3 kV) of appropriate size, link boxes, sheath voltage limiters and other accessories are to be provided. The link boxes should be suitable for



underground burial conforming to IP: 68 protection requirement and shall be housed in a common bay near the jointing bay. The length of sheath bonding cables should not exceed 10 mtrs.

Depending upon the route finally chosen, the PST contractor shall prepare drawing of Bonding, and shall establish that with the Bonding method adopted, the sheath voltages do not exceed the max permissible limit.

In case Cross Bonding becomes necessary, the sheaths have to be electrically transposed at every 'straight through joint' location and Sheath Voltage Limiters (SVL) may require to be



provided at 2 out of 3 Joint locations. This shall be decided during the drawing approval of the Bonding method.

The PST contractor will be required to submit the calculation that bonding method selected by him, single point bonding/ mid-point bonding/ cross bonding, ensures that the sheath voltage is limited to less than 65V in case of ultimate full loading of cable i.e. considering short time overloading also. Generally, cross bonding is to be used if feeder length is more than 2 kms.

- Bonding calculations shall be carried out as per latest IEEE 575.

4.2.8 Testing and Inspection

a) *Type-Tests*

All the equipment which are used for this work shall be of proven design and standards to achieve a very high level of reliability in service. An equipment is considered to be proven if it is in successful operation at least for a period of two years.

type test reports for 110kV, (E) or higher grade, single core, XLPE insulated, Aluminum/Copper conductor Aluminium or Copper Sheathed cable along with the bid, the PST contractor shall furnish a summary of type test reports for all the equipment listed below except those equipment which are yet to be type tested being under development within three (3) months period from the date of signing the contract.

- 66 kV (E) grade or above grade, Single Core 630, 800 sq.mm or above size XLPE insulated cable with Aluminum or Copper sheath.
- Heat Shrinkable type straight through joint suitable for 66 kV (E) grade or higher, Single core 800, 630 sq.mm or higher, XLPE insulated, Aluminum or Copper sheathed cable.
- Heat Shrinkable type cable terminations (indoor & outdoor) suitable for 66 kV (E) grade or higher, Single core 800, 630 sq.mm or higher, XLPE insulated, Aluminum or Copper sheathed cable.

The cable and cable accessories intended to be used for this work shall be:

- Type-tested within the last (5) year's period prior to the date of design approval
- Proven in service for at least two (2) years as on the date of design approval.

b) *Submission of Performance Certificates*

As a proof of satisfactory performance of following equipment during last two years from the bidder/JV partner /sub-PST contractor from whom Bidder intends to supply them.

The bidder shall furnish the necessary information in respect of all cables and accessories. The information will be used to finalize the sub-PST contractor sub-PST contractors for the particular equipment for this work

- 66 kV (E) grade or above grade, Single Core 630 sq.mm or above size XLPE insulated cable with Aluminum or Copper sheath.
- Heat Shrinkable type straight through joint suitable for 110kV (E) grade or higher, Single core 630 sq.mm or higher, XLPE insulated, Aluminum or Copper sheathed cable.
- Heat Shrinkable type cable terminations (indoor & outdoor) suitable for 110kV (E) grade or higher, Single core 630 sq.mm or higher, XLPE insulated, Aluminum or Copper sheathed cable.

c) *Type Test Results*

Summary of type test results of the above mentioned equipment will be in the following format:

Name of the equipment	Manufactured by	Rating	Governing Spec for type test	Name of test	Month/ Year conducted	Testing Lab/ Testing House/ manufacturer's works	Results/ Remarks
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If the type tests of any equipment being supplied for this work are not yet conducted by the PST contractor, then all the type tests as per the relevant IEC shall be conducted at his expense in the presence of employer's representative either at manufacturer's works having requisite facilities and approved by independent laboratory like KEEMA, Netherland or CESI Italy, or at KEEMA, Netherlands or CESI, Milano, Italy, CPRI INDIA

d) Details of Make of Cables/Accessories

The bidder shall submit to the employer the proposed "make" of all the above equipment in the bid form along with other details such as rating, quantity in use, place of installation number of years in satisfactory operation, summary of type test reports of required rating of

- ☐ 66 kV or higher grade, 630 sq.mm or higher size

Aluminum/copper conductor, XLPE insulated, Aluminum or Copper sheath cable along with the bid so as to decide the 'make' of the items. Based on the information thus furnished the employer shall decide the 'make' of the items to be used for the work.

The plant & equipment being supplied against this bid shall conform to relevant IEC standards.

The link box should be of stainless steel and conforming to protection class of IP 65 to avoid corrosion and entry of water. The thickness of stainless steel should be not less than 3 mm.

e) Rejection of Type Test Report

When the Employer rejects any specific type test report for particular equipment stating the grounds for such rejection, the PST contractor shall re-conduct the relevant type tests as per the specification in the presence of Employer's representatives before the item is supplied by him. Such type test shall be conducted by the PST contractor at his own expense at the manufacturer's works approved by KEMA Netherland or CESI Italy; CPRI INDIA in the presence of Employer's representative.

4.2.9 Type Test Reports

The type test reports of the equipment shall be of the tests carried out either at the manufacturer's works having requisite facilities or at KEEMA, Netherlands, CESI, Milano, Italy, and CPRI INDIA during the last **Five (5)** years period as on the **post bid vendor / make approval..** If any type test report is older than **-5** years, the type tests will have to be repeated at PST contractor's cost. Employer shall waive some of these tests in case of equipment / sub- assemblies where the manufacturer can establish to the satisfaction of employer that such tests have already been carried out earlier or where the equipment have been proved in service. In such a case, manufacturer shall submit complete test reports along with necessary certification.

4.2.10 Routine Tests

Routine tests shall comprise of visual inspection of the items and all the routine tests as per specification. All these tests shall be conducted in the presence of Employer's nominated representative at the manufacturer's works. Routine test shall be carried out as per specification IEC 60840/IEC 62067 latest versions.

a) *General*

The following tests shall be carried out on each manufactured length of cable:

- Partial discharge test
- Voltage test
- Electrical test on over sheath of the cable, if required.

The order in which these tests are carried out is at the discretion of the manufacturer. The main insulation of each prefabricated necessary shall undergo partial discharge and voltage tests according to either 1), 2) or 3) below:

- On accessories installed on cable
- By using a host accessory into which a component of an accessory is substituted for test
- By using a simulated accessory rig in which the electrical stress environment of a , main insulation component is reproduced.

In cases 2) and 3), the test voltage shall be selected to obtain electrical stresses at least the same as those on the component in a complete accessory when subjected to the test voltages specified.

NOTE: The main insulation of prefabricated accessories consists of the components that come in direct contact with the cable insulation and are necessary to control the electric stress distribution in the accessory. Examples are pre-moulded or pre-cast elastomer or filled epoxy resin insulating components that may be used singly or jointly to provide the necessary insulation or screening of accessories.

b) *Partial Discharge Test*

The partial discharge test shall be carried out in accordance with IEC 60885-3, IEC 62067 for cables, except that the sensitivity as defined in IEC 60885-3 shall be 10 pC or better. Testing of accessories follows the same principles, but the sensitivity shall be 5 pC or better.

The test voltage shall be raised gradually to and held at $1.75 U_0$ for 10 s and then slowly reduced to $1.5 U_0$. There shall be no detectable discharge exceeding the declared sensitivity from the test object at $1.5 U_0$.

c) *Voltage Test*

The voltage test shall be made at ambient temperature using an alternating test voltage at power frequency. The test voltage shall be raised gradually to $2.5 U_0$ and then be held for 30 min between the conductor and metallic screen/sheath. No breakdown of the insulation shall occur as per latest IEC 60840 /62067

4.2.11 Electrical test on over sheath of the cable

When the test is required by the particular contract, the cable over sheath shall be subjected to the electrical test specified in Clause 3 of IEC 60229.

4.2.12 Acceptance tests

a) General

Acceptance tests for the power cable & its accessories shall be carried out wherever the same is mentioned in the relevant specification governing the cable and its accessories. All the acceptance tests as mentioned in the governing specification to which the product is manufactured shall be conducted in the presence of Employer's nominated representative by the PST contractor at their manufacturing works.

The following tests shall be carried out on samples which, for the tests in terms b) may be drum lengths of cable, taken to represent batches:

- Conductor examination
- Measurement of electrical resistance of conductor and of metallic screen
- Measurement of thickness of insulation and over sheath
- Measurement of thickness of metallic sheath
- Measurement of diameters, if required
- Hot set test for XLPE, EPR and HEPR insulation Measurement of capacitance
- Water penetration test, if applicable
- Tests on components of cables with a longitudinally applied metal foil

b) *Frequency of tests*

The sample tests in items a) to f) and h) of 4.2.11 shall be carried out on one length from each batch (manufacturing series) of the same type and cross-section of cable, but shall be limited to not more than 10% of the number of lengths in any contract, rounded to the nearest whole number.

The frequency of the other tests as per relevant IEC shall be in accordance with agreed quality control procedures. In the absence of such an agreement, one test shall be made for contracts with a cable length above 20 km.

c) *Repetition of tests*

If the sample from any length selected for the tests fails in any of the tests in , further samples shall be taken from two further lengths of the same batch and subjected to the same tests as those in which the original sample failed. If both additional samples pass the tests, the other cables in the batch from which they were taken shall be regarded as having complied with the requirements of this standard. If either fail, this batch of cables shall be regarded as having failed to comply.

d) *Conductor examination*

Compliance with the requirements of IEC 60228 for conductor construction, or the declared construction, shall be checked by inspection and measurement when practicable.

e) Measurement of electrical resistance of conductor and metallic screen

The cable length, or a sample thereof, shall be placed in the test room, which shall be maintained at a reasonably constant temperature for at least 12 h before the test. If there is a doubt that the conductor or metallic screen temperature is not the same as the room temperature, the resistance shall be measured after the cable has been in the test room for 24 h. Alternatively, the resistance can be measured on a sample of conductor or metallic screen, conditioned for at least 1 h in a temperature-controlled liquid bath.

f) Additional Acceptance Tests

The following additional acceptance tests shall be carried out.

□ Additional acceptance tests (1 sample/offered lot) shall be carried out for Ovality & Eccentricity. Tensile strength and Elongation on insulation and over sheath before

and after ageing and Thermal Stability on outer sheath of power cable.

- Surface finish and length measurement shall be carried on one length of each size of offered lot of power cables.

g) Short Circuit Test:

Short Circuit test for Power Cables will be conducted by the PST contractor on the cable at Manufacturer's works having requisite facilities approved by KEMA Netherlands or CESI Italy or at KEEMA, Netherlands or CESI Milano Italy, CPRI INDIA & shall be witnessed by the Employer's authorized representative.

4.2.13 Test Certificates

Three copies of the test certificates of successful type tests if any carried out on cables and cable accessories shall be furnished to the Employer within fifteen days after completion of such type tests.

Three copies of successful acceptance & routine tests carried out on cables and cable accessories and the certificate of inspection issued by the Employer's representative shall be furnished within 15 days, after the completion of tests by the Employer's representative.

4.2.14 Responsibility of PST contractor for Delivery/Supply

- All defects detected as a result of testing / inspection shall be rectified by the manufacturer at his own expense and shall be documented and corrected prior to shipment. If in the opinion of Employer, a repeat of the test is required after such rectification, this shall also be carried out at the expense of the PST contractor .
- No cable / accessory shall be supplied until Employer has inspected the same to his satisfaction and accepted. However, such inspection and/or acceptance certificate shall not relieve the PST contractor of his responsibility for furnishing the cables and cable accessories conforming to the requirements of the contract nor prejudice any claim, right or privilege which the Employer may have because of the use of defective or unsatisfactory items. Should the Employer waive the right to inspect any item, such

waiver shall be obtained by the PST contractor from the Employer in writing and such a waiver shall not relieve the PST contractor in any way from his obligation under the contract.

- Only after obtaining clearance from the Employer, the PST contractor shall dispatch the items to site.

4.2.15 Inspection of Erection Work

All erection work will be subject to inspection by the Employer or his representative to ensure that the work is done in accordance with the specification and approved drawing. Bonding of cable joints at SVL shall be jointly verified by the PST contractor and BSTP (O&M and Project) representative and shall also be certified for proper connection by third party validator appointed by PST contractor.

4.2.16 Inspection and Tests of Completely Laid Cable

a) General

As soon as the work is completed and ready for inspection and testing, the PST contractor shall advise the Employer in writing. Tests will be carried out by the Employer jointly with the PST contractor. Testing equipment and staff required for the tests shall be provided by the PST contractor free of charge. The PST contractor shall take full responsibility for these tests inter alia his other responsibilities.

The PST contractor shall notify the manufacturer of cable and cable accessories regarding likely date of pre-commissioning tests, one month in advance so that their representative may be available at site at the time of conducting the tests. It shall be PST contractor's responsibility to ensure that the cable and its accessories are commissioned as per laid down procedures.

b) Pre commissioning Tests for the facility as a whole

The following site tests shall be conducted on a completed power cable installation as per specification IEC 60840/62067 latest versions.

(i) Visual Inspection and Continuity Check

Visual inspection shall include check for satisfactory workmanship. Continuity check shall be carried out on the cable to ensure that the cable is continuous.

(ii) DC voltage test of the over sheath

The test shall be conducted as per Clause 15.1 of IEC 60840 or relevant clause of IEC 62067.

(iii) AC voltage test for the installation.

The test shall be conducted as per Clause 15.2 of IEC 60840 or relevant clause of IEC 62067.

- (iii)** The insulation resistance of the cable shall be checked before & after the HV test on cable. The core resistance shall be measured, and the value corrected in accordance with clause 5 of IEC 60228.

- (iv) The cable must be discharged on completion of DC High Voltage Test and the cable shall be kept earthed until it is put into service. The values obtained during these tests shall be in conformity with the values obtained during inspection of the materials at the manufacturer's works.

c) Proforma for Tests

The PST contractor shall submit the results of tests in quadruplicate in an approved proforma within 7 days from the date of completion of the tests but before actual commissioning of the cable. The proforma shall be developed by the PST contractor and got approved from Employer within three (3) months from the effective date of the contract.

4.3 Medium Voltage 33 kV Cables

Detailed description of the equipment and its application in BSBRP - Medium voltage cables. These specifications are applicable to 33 kV cables in various corridors, constituting the 33 kV distribution network.

33 kV Cables are required to be used in the Auxiliary Network, for supply of power at 33 kV to various ASSs located at Stations and in the Depot. The Auxiliary Network consists of duplicate 33 kV feeders, each feeder consisting of 3 Single core cables, the Cross section of the conducting core generally used is as follows for various connections: Location; From Auxiliary Transformer to 33kV Switchgear in RSS	Conducting Core 120 sq. mm Aluminum
33 kV CB to Transformer (33 kV/415 V) (less than and up to 3 MVA) (Length should not be less than 25mtrs.)	120 sq. mm Aluminum

The elevated corridor ASSs shall be supplied from a 33 kV cables Network, which shall consist of two cables (cable 1 and cable 2) normally independent from one another. The network is divided into loops, as necessary, as shown in the relevant 'Auxiliary Power Supply scheme.

The 33 kV distribution cables in the elevated sections shall be laid inside cable path/channels provided on the viaduct along the tracks. Current rating for cables shall be determined taking into consideration the following installation methods as applicable:

- Buried in Ground
- In the tunnels
- On brackets in the trenches
- Ducts/Pipes/Trenchless pipes

And on the following as per design data:

- temperature correction
- Soil thermal resistivity
- Depth of laying in ground
- Type of laying and cables pacing
- Cable grouping factor etc.

4.3.1 Governing Specifications

The 33 kV Cables shall conform to IEC 60502 and shall be of 18/30 kV (36 kV). The cables shall be of dry-insulated, radial-field cable, based on proven technology. They shall be constituted by assembly of three single core cables in twisted or cloverleaf pattern, annealed stranded compacted circular Copper conductor or stranded Al Conductor for the cables as specified. The cable shall be XLPE insulated with semi-conducting screen over conducting core. The cable shall also be Tape armored. It shall conform to IEC 60502 Part 2 latest for construction and for testing.

4.3.2 Standards

The 33 kV Cables shall satisfy the following requirements and shall also comply with standards in force when the cables are manufactured, particularly which are in the following table (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable): -

Standard #	Description
IEC-60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)"
IEC-60228	Conductors of insulated cables
IEC-60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) - Test methods and requirements
IEC-60332	Part 1: Tests on electric and optical fiber cables under fire conditions Part 3: Tests on electric cables under fire conditions
IEC-60811	Electric and optical fiber cables - Test methods for non-metallic materials
IEC-60754	Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content
ASTM D - 2843	Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics
ASTM D - 2863	St Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)

IS-7098 Part 2	Cross linked polyethylene insulated thermoplastic sheathed cables, Part 2: for working voltages from 3.3 KV up to & Including 33 KV.
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4.3.3 Abbreviations

- IEC – International Electro technical Council
- ASTM - American Society for Testing and Materials
- AMS – Auxiliary Main Substation
- ASS – Auxiliary Sub Station
- RSS – Receiving Sub Station
- XLPE – Cross Linked Poly Ethylene
- FRLS – Fire Retardant Low Smoke
- FRLSZH – Fire Retardant Low Smoke Zero Halogen
- CB – Circuit Breaker
- PD – Property Development
- IS – Indian Standard

4.3.4 Technical Requirement

The cables shall be insulated with chemically cross-linked polyethylene (XLPE), with semi-conducting screen over a copper conducting core, insulating envelope Aluminum Tape armoring and suitable protective sheath.

- operating voltage: 33 kV rms between phases,
- specified voltage: 18/30 kV rms (According to IEC 60502)
- Conductors as specified

The PST contractor shall calculate cross section area of the cable as per the required current carrying capacity of transformer with overloading condition and other load requirement and to verify cross-sectional area of these cables as regard to the actual laying arrangement and design data

All cables whether Fire Retardant Low Smoke (FRLS) to be used in elevated sections or Fire-Retardant Low Smoke Zero Halogen (FRLSZH) to be used in the Underground Sections shall conform to IEC 60502 or equivalent. The cables, in addition, shall be non-fire propagating, non-toxic and low smoke producing type.

The various constructional features required for the 33 kV cables are as under:

4.3.4.1 Conducting Core

The conductor shall be formed from annealed compact circular stranded class-2 Copper conductor or compact circular stranded class-2 Aluminum Conductor, as the case may be, complied with IEC latest publications 60228. The conductor shall be compact circular stranded.

4.3.4.2 Conductor:

The conductor shall be formed from annealed Stranded compacted circular Copper conductor (or stranded Aluminum Conductor as the case may be) complied with IEC latest publications 60228. The conductor shall be compact circular stranded.

4.3.4.3 Conductor Screen:

The conductor screen to be provided as per Clause 7.1 IEC 60502-2:2005 or equivalent clause in latest version of IEC 60502-2. The conductor screen shall consist of suitable thickness and volume resistivity. It shall be easily removable from conductor during jointing. Nominal thickness of conductor screen shall be 0.7mm.

4.3.4.4 Insulation:

The Insulation shall be XLPE complying with IEC60502 and IEC 60811. The insulation shall have a higher degree of Cross- Linking, free from contaminants and air voids, heat resistant and shall be applied by the extrusion process.

The XLPE insulation shall be suitable for use on power cable in wet and dry locations at conductor temperature as per IEC 60502-2. For this purpose, short circuit current in conductor is to be considered as 7 kA for 3 sec.

The conductor with screening shall be provided with cross-linked polyethylene (XLPE) insulation applied by extrusion. The nominal thickness of insulation shall not be less than 9 mm as per IEC 60502-2 and subject to tolerance as per IEC – 60840, clause 10.6.2. Alternatively, higher thickness of insulation as per IS 7098 with specified eccentricity in IS 7098 will also be accepted.

The insulation compound shall be of high quality, and shall be heat, moisture, ozone and corona resistant. XLPE compound should be from reputed manufacturer e.g. Borealis Sweden or NUC Japan or equivalent with satisfactory service experience of more than 5 years. The Insulation shall be applied by triple extrusion and vulcanized using dry curing process to form a compact homogenous body free from micro voids and contaminants. Make of the XLPE, will be approved by the Engineer, before giving manufacturing clearance.

4.3.4.5 Insulation Screen:

The Insulation screening shall be applied direct upon the insulation as per IEC 60502-2. The screen shall be tightly fitted to the insulation to exclude all air voids and still it could be easily stripped on site. Semiconducting compound should be from a reputed manufacturer eg. Borealis, Sweden or NUC Japan or equivalent with satisfactory service experience of more than 5 years. Nominal thickness of insulation screen shall be 0.7mm.

The conductor screen, insulation & insulation screen shall be extruded in a single process (triple extrusion).

4.3.4.6 Water

Barrier:

Longitudinal:

The water barrier shall be semi-conducting water swellable tape to be applied over the extruded insulation screening to block and prevent moisture propagation in a longitudinal direction. The semi-conducting tape shall be suitable for the operating temperature of the cable

and compatible with the insulation.

4.3.4.7 Metallic Screen:

The metallic screen shall be plain copper round wire and copper tape applied helically over the semi-conductor bedding tape(s). An annealed plain copper binder tape shall be applied in the form of an open helix, over the copper wire screen. The area of the copper wire /copper tape should be able to withstand specified earth fault current (minimum 1 kA for 3 sec). Bidder to submit the calculations giving details of the area of copper wire/ copper tape screen.

The three-phase short-circuit current capacity of metallic screen is to be considered, 1 kA (for the cables to be fed by substations where Neutral Grounding Resistor (NGR) is installed). The sheath shall be impervious to moisture, reasonably close fitting and free from defects and impurities such as oxide, which give rise to failure under working conditions.

4.3.4.8 Inner Sheath:

A polypropylene tape shall be applied over the metallic screen. For FRLSZH cables where applicable an inner layer of FRLSZH tape shall be applied over metallic screen followed by Polyethylene laminated Aluminum tape.

4.3.4.9 Armoring:

Double Tape Aluminum armoring should be applied over the inner sheath and the thickness of the same should be as per IEC 60502.

4.3.5 Short Circuit Rating of Metallic Sheath/Screen

The area of copper wires/copper tape shall be designed to meet the requirement of the system short circuit rating of 1 kA for 3 Seconds.

4.3.6 Outer Sheath

The outer sheath to be provided as per IEC 60502-2.

4.3.7 Additional Requirement

Cables laid on viaduct & ramps shall be exposed to sun, therefore such cables shall be capable of withstanding ultraviolet radiation. They shall be black in colour with identification for Red, Yellow & Blue phases which can be clearly seen without efforts throughout the run.

4.3.8 Outer Sheath should have following features:

- Cables laid in elevated sections shall be exposed to sun. The outer sheath shall be extruded in black colour with UV Protection, FRLS PVC conforming to the requirement of IEC specifications and extruded continuously. **Such cables shall have phase identification after interval of 10 meters. Colour coding shall be done at manufacturer's works. The details of compound used for outer sheath shall be submitted.**
- For Underground cables the outer sheath shall be flame retardant polyolefin conforming to the requirement of IEC specifications and extruded continuously. Outer sheath shall be treated with Anti Termite/ Anti pest/ Anti rodent & corrosion Resistant Compound.

The sheath shall be resistant to water, ultraviolet radiation, fungus attacks, conforming to the requirement of IEC specifications and extruded continuously. The details of compound used for outer sheath shall be submitted.

- The PST contractor shall confirm the cross section of the cables in as regard to:
 - the route installation,
 - the thermal conditions in service,
 - the climatic conditions,
 - the energy and currents flowing through these cables, taking into account the worst electrical conditions,
 - operation under permissible overload conditions,
 - operation under permissible overload conditions when all 33 kV distribution are
 - supplied by only one transformer, and on only one 33 kV cable.
- The protective sheath shall carry the indications listed below, in letters and digits at least 6 mm high:
 - Designation of ownership,
 - Nature and cross-sectional area of conductors,
 - Specified cable voltage,
 - phase numbering,
 - Manufacturer's name
 - Length of cable shall be marked at 1 m interval.
 - Year and month of manufacturing
- The cable shall be manufactured by a company having ISO accreditation for quality. The cable manufacturer shall have NABL accredited laboratory facility to conduct routine and acceptance test.
- The PST contractor shall provide trefoil clamps of non-metallic/metallic & non-magnetic sturdy type as per IEC 61914 at every 5 meters with cable ties at every meter. Material of cable tie shall be approved by the Engineer. Cable ties should last for 35 years.
- The manufacturing process of XLPE cable shall consist of conductor screen, insulation & insulation screen which shall be extruded in a single process. (Triple extrusion) and cross linked by a standard Process of dry curing technology to ensure homogeneity and absence of micro voids. The cables shall be manufactured by "Dry Curing" Process.
- The Employer may decide to visit the works of cable manufacturer to verify the manufacturing process mentioned.
- The Bidder along with the Bid, shall submit the details regarding cable construction, bill of material the manufacturing process proposed to be adopted for the manufacturing of 33 kV cables to be used in the project, along with Quality control measures adopted by the Manufacturer, to ensure :-

- > The values and tolerances are strictly as per IEC.
- > The cable manufacturer exercises strict quality control measures, including stage inspections, routine inspections etc. to ensure conformity to standards.

Periodical inspections of the Manufacturer work, manufacturing processes, Internal Quality control records of the manufacturer etc. shall be carried out by the User (BSBRP/Nominated agency), to ensure compliance to Quality standards.

- (x) Each end of the cable in cable drum shall be covered with heat shrinkable tape to avoid water ingress during the storage and transportation. The cable drum without heat shrinkable tape shall be rejected.

4.3.9 Maintenance & Life

The cable should be designed for maintenance free service of minimum 30 years for all types of installation & under prescribed environmental conditions

Special Condition

All type of 33kV Cables to be used shall be FRLS Type. Cables from AMS to ASS shall also be FRLS. The manufacturer shall have laid down in-house selection process of the raw material used and shall submit all details, if equivalent raw material is used whenever specified.

4.3.10 Testing

- a) All type tests to be conducted as per IEC 60502-2. The 33 kV cable shall comply with following Test Standards in addition to test standards of IEC 60502: Type tests shall not be more than 5 years old.
 - IEC 60332 Part 1 and 3, category A, test on single and bunched cables under fire condition.
 - Limiting Oxygen Index at least 30 tested as per ASTM D-2863.
 - Temperature index of minimum 250 deg C as per IS 7098 (Part-2).
 - Smoke density Test (on sheathing material), when tested in accordance to ASTM D-2843, maximum smoke density rating shall be 60 as per IS 7098 Part – 2. This will be applicable for FRLS Cable.
 - All Insulation is to be moisture and heat resistant with temperature rating appropriate to the application conditions and in no case lower than 90 deg C.

In addition to the above FRLSZH cables used in U/G section shall also comply with following test standards: -

- Determination of the amount of halogen Acid Gases as per IEC 60754 Part 1 (Maximum HCL gas shall not exceed 0.5%) and IEC 60754 Part –II

- Smoke density Test (on sheathing material), when tested in accordance to ASTM D-2843, maximum smoke density rating shall be 30 as per IS 7098 Part – 2. This will be applicable for FRLSZH Cable.
- b) The user may ask repetition of the following type tests –
- Bending Test
 - Tan δ measurement for cables
 - Impulse test followed by a voltage test for 4 hrs.
- c) The manufacturer shall not change the Bill of Material used in the manufacturing of samples for routine and Type testing as repeated above and in cables intended to supply against the contract

4.3.11 Data Sheet - 33 kV

Cables As per GTP.

4.3.12 Connecting Junctions - MV

Ends a) *Connecting Junctions*

Connecting junctions shall reconstitute perfectly all elements of the MV cables, so as to obtain electrical and mechanical characteristics at least equal to those of the cable. The PST contractor shall submit to the client, for approval, a detailed description of the technique foreseen for execution of connections in MV lines.

However, maintenance and repair being able to be carried out only during a short period of time, at night, due consideration shall be given to connection processes having the following characteristics, quality being otherwise equal:

- quickness of execution,
- possibility of replacement without having to disturb the cable,
- small bulk.

The Straight through joints shall be Heat Shrink Type with shear head type mechanical connectors or Cold Shrink type of proven technology and make.

b) *Cable Heads*

MV cable heads shall be connected to cable junction boxes with the MV apparatus. The Sealing Ends shall be Heat Shrink Type with shear head type mechanical connectors or Cold Shrink type of proven technology and make.

c) *Execution Rules*

The entire supply shall be executed according to all Rules of the Art pertaining to professional-grade equipment, and in compliance with the technical specifications and specifications of the International Electrotechnical Commission relative to power supply cables (IEC 55-1, 55-2 and

502-1). The supply shall be delivered, upon request by the client, only after execution of in-plant inspection operations and satisfactory testing according to the technical requirements imposed.

The cables shall pass all the tests stipulated in the IEC 502 rules in force on the date of the order. The sleeves and the insulating materials used shall meet the guarantee requirements imposed. The equipment shall be capable of withstanding intensive use without alteration, and of performing its duty even after extended idle period.

d) Atmospheric and Climatic Conditions

The entire equipment shall be designed for operation in hot weather, according to the climatic conditions. The equipment shall be sturdy and properly treated against corrosion. This protection shall be suited to the various environmental conditions encountered in the various parts of the network. It must be noted that environmental conditions shall be very severe during construction; these conditions shall not be the cause of any alteration of equipment or material whether already installed or simply stored.

e) Cable Technical and Test Sheet

laying of the cable and its accessories, a dielectric test is carried out through application, for 15 minutes, of the tests shall be performed according to the corresponding IEC standard. After completion of alternating voltage equal to square root $3.U$ or a direct voltage equal to $4.U$.

4.3.13 Cable Laying Specification

a) General

Description	Single Core	Three Core
a) 400 sq mm Copper		
- overall dia (mm)	49	103
- Weight in kg/km	5070	16820
- Standard length per drum (m)	500	200
b) 150 sq mm Aluminium		
- overall dia (mm)	39	81
- Weight in kg/km	1510	5420
- Standard length per drum (m)	500	500

MV cables shall be laid in cable trenches or in pipes. The cables have the following approximate overall diameter and linear weights

b) Cable Routing

In the Receiving Substation

Routing of the MV cables between the transformers and the incoming circuit breakers shall be realized in cable channel going up from transformers secondary windings to the cable head of the incoming circuit breaker cell. Each connection from the transformer to the circuit breaker shall be made with suitable number of runs of XLPE cables, each with 3 single core cables (or with a 3-core cable), with conductor cross-section of 400 mm² copper.

Laying between the AMS and the Line

Routing of the MV cables between the AMS and the line shall be made according to the following principle:

- from the outgoing circuit breakers downstream to the base of the viaduct: into cable channel and duct
- from base of the viaduct to the line: on cable tray. They shall be fixed on the cable tray every 0.75 m and on each side of change of way.

Laying in Viaduct

Cables shall be laid on the parapet wall of the via-duct with suitable cable layers supports suitable for outdoor applications under the walkway.

c) Cables Installation

Laying out

The cables shall be delivered to the site in lengths of about 200 mtr to 500 mtr, coiled on drums whose total weight (with cables), shall not normally exceed 8000 kg. At every termination, the cables shall be provided with a loop of approximately 2m-3m to cater to maintenance requirements, in future. If cables are laid after the track is in position, then these reels shall be delivered by train as close as possible to the point of utilization, accounting for the constraints generated by the actual traffic on the existing line.

Paying out of the cables can be made manually or mechanically. The mechanical devices (electric or pneumatic) used for paying out the cables shall be constructed so as to prevent damaging the cables. These devices shall be submitted to the client's representative for approval. Should mechanically paying out not accepted, for whatever reason, the PST contractor shall execute paying out of the cables with the number of personnel deemed necessary by the client's representative.

The laying team shall be under the authority of a supervisor qualified for this type of work. To execute paying out, this supervisor shall comply with the instructions given by the client's representative in charge of technical supervision of cable laying. All necessary precautions shall be implemented during operation to prevent any deterioration of the cable; the cable shall not be subjected to any twisting around its axis, and not be bent to a radius smaller than 1.5 meter. It shall be subjected only to the traction efforts strictly required to pay it out. In no event may the cable bear against the ground or against fixed stops; it shall rest onto rollers, situated sufficiently close to one another. The ends of two successive reel lengths shall overlap by about two meters to enable cropping the cable ends before execution of the connection sleeves.

When the client's representative estimates that paying out of cables in a single length 200 to 500 m risks generating abnormal strains in the cable, one or several looping may have to be made. A cable looping is defined as being any operation that requires previous paying out of the cable outside the channel or cableways. When two cable courses are superimposed inside channels, each course shall be separated by means of isolating plates every 3 m.

Tagging

All cables laid inside channels, or on cable-tray shall carry an 8 x 5 cm PVC tag placed

every 10 m and in specific locations such as connection sleeves, entry into and exit from ducts, possible pulling chambers. These tags, fastened via two clamps, shall bear the Organization approved label.

Tagging of cables playing a part in safety as regard identification of the cables in case of incident, shall be made very carefully and the PST contractor shall be held responsible for any error or for any incident subsequent to such an error. The tags shall be fastened right after the paying out of each reel.

4.4 25 KV CABLES

Detailed description of the equipment and its application in BSTP - 25 kV cables These specifications are applicable to 25 kV cables in various corridors, constituting the 25 kV Traction Power supply distribution and Overhead Equipment Traction network. 25 kV Cables are generally required for the following connections:

- From Traction Transformer Secondary to 25 kV Switchgear (AIS, GIS and Hybrid)
- Connections between 25 kV equipment, as necessary, in the TSS
- Any other location as required

Cable of copper conductor with cross section of 240 Sq.mm/Aluminum conductor with cross section 400 sq.mm. is generally used; however different cross section may also be used as required subject to approval of engineer.

4.4.1 Current Rating

Current rating for cables shall be determined taking into consideration the following installation methods as applicable:

- Buried in Ground
- In the tunnels
- On brackets in the trenches
- Ducts/Pipes/Trenchless pipes

And on the following as per design data:

- temperature correction
- Soil thermal resistivity
- Depth of laying in ground
- Type of laying and cable spacing
- cable grouping factor etc.

4.4.2 Governing Specifications

25 kV Cables shall conform to IEC 60840 with specified voltage as 26/45 kV (52 kV) grade. The cables shall be of dry-insulated, radial-field cable, based on proven technology

4.4.3 Standards

The 25 kV Cables shall satisfy the requirements given below and shall also comply with standards in force when the cables are manufactured, particularly which are in the following table. (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable): -

Standard #	Description
IEC-60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)"
IEC-60228	Conductors of insulated cables
IEC-60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) - Test methods and requirements
ASTM D-2843	Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics
ASTM D-2863	Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
IS-7098 Part 2	Cross linked polyethylene insulated thermoplastic sheathed cables, Part 2: for working voltages from 3.3 KV up to & Including 33 KV.

4.4.4 Abbreviations

- IEC – International Electro technical Council
- ASTM- American Society for Testing and Materials
- IS- Indian Standard
- TSS – Traction Sub Station
- ASS – Auxiliary Sub Station
- RSS – Receiving Sub Station
- OHE – Over Head Equipment
- XLPE – Cross Linked Polyethylene
- FRLS – Fire Retardant Low Smoke
- FRLSZH – Fire Retardant Low Smoke Zero Halogen
- FP – Feeding Post
- SP- Sectioning Post
- SSP – Sub Sectioning and Paralleling Post
- SS – Sub Sectioning Station

4.4.5 Technical Requirement

- a) 25 kV cable shall be single core, stranded copper conductor, XLPE insulated,
- b) copper wire screened, tape armoring, sheathed cables. It shall conform to IEC 60840 latest versions for construction and testing. However different cross section may also be used as required.
 - operating voltage: 25 kV rms between phase and Ground,
 - specified voltage: 26/45 kV rms (according to IEC 60840)
 - Copper conductor as per IEC 60228
- c) The PST contractor shall calculate cross section area of the cable as per the required current carrying capacity of transformer with overloading condition and other load requirement and to verify cross-sectional area of these cables as regard to the actual laying arrangement and design data mentioned in respective Para.
- d) The various Constructional features required for the 25 kV cables are as under:

Conductor

The conductor shall be formed from annealed copper conductor with required size according to class 2 (Stranded compact circular) complied with IEC 60228 latest publication.

Conductor Screen

The conductor screen shall be non-metallic and shall consist of an extruded semiconducting compound, which may be applied on top of a semi conducting tape. The extruded semi-conducting compound shall be firmly bonded to the insulation.

Insulation

The Insulation shall be XLPE. The insulation shall have a higher degree of Cross-Linking, free from contaminants and air voids, heat resistant and shall be applied by the extrusion process. The XLPE insulation shall be suitable for use on power cable in wet and dry locations at conductor temperature as per IEC 60840. For this purpose, short circuit current in conductor is to be considered as 16 kA for 3 seconds.

The conductor with screening shall be provided with XLPE insulation applied by extrusion. The nominal thickness of insulation shall not be less than 10 mm subject to tolerance as per IEC – 60840, clause 10.6.2. The insulation compound shall be of high quality, and shall be heat, moisture, ozone and corona resistant. XLPE compound should be from reputed manufacturer e.g. Borealis Sweden or NUC Japan or equivalent with satisfactory service experience of more than 5 years. The Insulation shall be applied by triple extrusion and vulcanized using dry curing process to form a compact homogenous body free from micro voids and contaminants.

Insulation Screen

The insulation screening shall be applied direct upon the insulation and shall be of a layer of extruded semiconducting thermosetting compound firmly and totally

bonded to the insulation. Semiconducting compound should be from a reputed manufacturer e.g. Borealis, Sweden or NUC Japan or equivalent with satisfactory service experience of more than 5 years.

The conductor screen, insulation & insulation screen shall be extruded in a single process (triple extrusion) and cross

linked by dry curing technology to ensure homogeneity and absence of micro voids. The screen placed over the insulating envelope shall consist of a nonmetallic semi-conducting part, associated to a metallic part. The non-metallic part, consisting of a semi-conducting material, will be easily separable from the insulant in order to facilitate cleaning of the latter. This semi-conducting material will have to constitute a mat which protects the insulation from expansion strains. The metallic part applied over the semi-conducting part will consist of stranded wire with copper tape.

Water Barrier:

The water barrier shall be semi-conducting water swellable tape to be applied over the extruded insulation screening to block and prevent moisture propagation in a longitudinal direction. The semi-conducting tape shall be suitable for the operating temperature of the cable and compatible with the insulation.

Semiconducting Tape

The semiconducting tape(s) should be applied over the insulation screen.

Metallic Screen

The metallic screen shall be plain copper round wires applied helically over the semi-conductor bedding tape(s). The Area of copper wire shall be able to withstand specified earth fault current. Bidder has to submit the calculations giving details of the area of copper wire screen. An annealed plain copper binder tape shall be applied in the form of an open helix, over the copper wire screen.

Inner Sheath

The Inner sheath shall be provided with extruded PVC compound.

Armoring

Double Tape Aluminum armoring should be applied over the inner sheath and the thickness of the same should be as per IEC 60502 as applicable.

Outer Protective Sheath

The anti-corrosion outer protective sheath, applied directly over the metallic screen, whose grade is compatible with the operating temperature of the cables; it must ensure protection against corrosion. The nominal thickness of this sheath will be determined according to the requirements set forth in standard IEC 60502.

The cable shall be insulated with XLPE, with semiconducting screen over a copper conducting core and insulating envelope and FRLS PVC protective sheath for the cables to be laid outside.

Additional Requirement

The protective sheath will carry the indications listed below, in letters and digits at least 6 mm high:

- designation of ownership
- nature and cross-sectional area of conductors
- specified cable voltage
- phase numbering
- manufacturer's name

d) Short Circuit Rating of Metallic Sheath/Screen

The area of plain copper round wire screen shall be designed to meet the requirement of the system short circuit rating of 16 kA for 3 seconds.

The cables shall pass all the tests stipulated in the IEC standards in force on the date of the order. The sleeves and the insulating materials used shall meet the guaranteed requirements imposed.

The equipment shall be capable of withstanding intensive use without alteration and performing its duty even after extended idle period.

4.4.6 Atmospheric and Climatic Conditions

The entire equipment will be designed for operation in hot weather, according to the climatic conditions defined in General Specifications. The equipment will be sturdy and properly treated against corrosion. This protection shall be suited to the various environmental conditions encountered in the various parts of the network.

It must be noted that environmental conditions will be very severe during construction; these conditions shall not be the cause of any alteration of equipment or material whether already installed or simply stored.

4.4.7 Maintenance & Life

The cable should be designed for maintenance free best service life best in the industry and not less than 30 years for all types of installation & under prescribed environmental conditions.

4.4.8 Special Conditions

- The manufacturer shall have laid down in-house selection process of the raw material used and shall submit all details, if equivalent raw material is used wherever specified.
- The cable shall be manufactured by a company having ISO accreditation for quality. The manufacturing process of XLPE cable shall consist of conductor screen, insulation & insulation screen which shall be extruded in a single process. (Triple extrusion) and cross linked by a standard Process of dry curing technology to ensure homogeneity and absence of micro voids.
- The Employer may decide to visit the works of cable manufacturer to verify the manufacturing process mentioned.

The Bidder along with the Bid, shall submit the details regarding cable construction, bill of material the manufacturing process proposed to be adopted for the manufacturing of cables to be used in the project, along with Quality control measures adopted by the Manufacturer, to ensure: -

- The values and tolerances are strictly as per IEC.
- The cable manufacturer exercises strict quality control measures, including stage inspections, routine inspections etc. to ensure conformity to standards.

Periodical inspections of the Manufacturer work, manufacturing processes, Internal Quality control records of the manufacturer etc. shall be carried out by the User (BSBRP/Nominated agency), to ensure compliance to Quality standards.

4.4.9 Testing

- a) The manufacturer shall submit type test results of 25 kV cable along with vendor approval proposal as per IEC 60840 and shall not be more than 5 years old at the time of post bid vendor / make approval.

- b) The 25 kV cable shall comply with following Test Standards in addition to test standards of IEC 60840:
- IEC 60332 Part 1 and 3, category A, test on single and bunched cables under fire condition.
 - Limiting Oxygen Index at least 30 tested as per ASTM D-2863.
 - Temperature index of minimum 250 deg C as per IS 7098 (Part-2).
 - Smoke density Test (on sheathing material), when tested in accordance to ASTM D-2843, maximum smoke density rating shall be 60 as per IS 7098 Part – 2. This will be applicable for FRLS Cable.
 - All Insulation is to be moisture and heat resistant, with temperature rating appropriate to the application conditions and in no case lower than 90 deg C.

In addition to the above FRLSZH cables used in Underground section shall also comply with following test standards: -

- Determination of the amount of Halogen Acid Gases as per IEC 60754 Part 1 (Maximum HCL gas shall not exceed 0.5%) and IEC 60754 Part –II
 - Smoke density Test (on sheathing material), when tested in accordance to ASTM D-2843, maximum smoke density rating shall be 30. This will be applicable for FRLSZH Cable.
- c) The purchaser may ask repetition of the following type tests as per IEC 60840 –
- Bending Test
 - Tan δ measurement
 - Heating Cycle voltage test
 - Lightning Impulse voltage followed by a power frequency voltage test
 - Partial discharge test
 - Examination of the cable system with cable and accessories on completion of above tests.
- d) The client will deliver the supply, upon request, only after execution of in-plant inspection operations and satisfactory testing according to the technical requirements imposed.
- e) The manufacturer shall not change the Bill of Material used in the manufacturing of samples for routine and Type testing as repeated above and in cables intended to supply against the contract

4.4.10 Data Sheet- 25 kV**Cables As per GTP.****4.4.11 Connecting Junctions**

Connecting junctions shall reconstitute perfectly all elements of the 25kV cables, so as to obtain electrical and mechanical characteristics at least equal to those of the cable. At every termination, the cables shall be provided with a loop of approximately 2m-3m to cater to maintenance requirements, in future. The PST contractor will submit to the client, for approval, a detailed description of the technique foreseen for execution of connections in MV lines.

However, maintenance and repair being able to be carried out only during a short period of time, at night, due consideration shall be given to connection processes having the following characteristics, quality being otherwise equal:

- quickness of execution,
- possibility of replacement without having to disturb the cable,
- small bulk.

The Straight through joints and Sealing Ends shall be Heat Shrink Type with shear head type mechanical connectors or Cold Shrink type of proven technology and make.

4.4.12 Execution Rules

The entire supply will be executed according to all Rules of the Art pertaining to professional-grade equipment, and in compliance with the technical specifications and specifications of the International Electro technical Commission relative to power supply cables (IEC 840). The client will deliver the supply, upon request, only after execution of in-plant inspection operations and satisfactory testing according to the technical requirements imposed.

The cables shall pass all the tests stipulated in the IEC rules in force on the date of the order. The sleeves and the insulating materials used shall meet the guaranteed requirements imposed. The equipment shall be capable of withstanding intensive use without alteration, and of performing its duty even after extended idle period.

4.5 3.3 KV CABLES**Detailed description of the equipment and its application in BSTP – 3.3 kV cables**

These specifications are applicable to 3.3 kV Traction Return cables in various corridors, constituting the 25 kV Traction Power supply distribution and Overhead Equipment Traction network.

3.3 kV Cables are generally required for the following connections:

> From Traction Transformer Secondary to Buried Rail in the TSS

Cable of copper conductor with cross section of 240 sq. mm. is generally used; however different cross section may also be used as required subject to approval of engineer.

4.5.1 Current Rating

Current rating for cables shall be determined taking into consideration the following installation methods as applicable:

- Buried in Ground
- In the tunnels
- On brackets in the trenches
- Ducts/Pipes/Trenchless pipes

And on the following as per design data:

- temperature correction
- Soil thermal resistivity
- Depth of laying in ground
- Type of laying and cable spacing
- cable grouping factor etc.

4.5.2 Governing Specifications

The 3.3 kV Traction Return cables shall conform to IEC 60502 with specified voltage as 1.8/3.0 kV (3.6 kV) grade. The cables shall be of dry-insulated, radial-field cable, based on proven technology.

4.5.3 Standards

The 3.3 kV Cables shall satisfy the requirements given below and shall also comply with standards in force when the cables are manufactured, particularly which are in the following table. (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable): -

4.5.4 Abbreviations

- IEC – International Electro technical Council
- ASTM- American Society for Testing and Materials
- IS- Indian Standard
- TSS – Traction Sub Station
- ASS – Auxiliary Sub Station
- RSS – Receiving Sub Station

Standard #	Description
IEC-60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)"
IEC-60228	Conductors of insulated cables
IEC-60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) - Test methods and requirements
ASTM D-2843	Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics
ASTM D-2863	Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
IS-7098 Part 2	Cross linked polyethylene insulated thermoplastic sheathed cables, Part 2: for working voltages from 3.3 KV up to & Including 33 KV.

- OHE – Over Head Equipment
- XLPE – Cross Linked Polyethylene
- FRLS – Fire Retardant Low Smoke
- FRLSZH – Fire Retardant Low Smoke Zero Halogen
- FP – Feeding Post
- SP- Sectioning Post
- SSP – Sub Sectioning and Paralleling Post
- SS – Sub Sectioning Station

4.5.5 Technical Requirement

- a) 25 kV cable shall be single core, stranded copper conductor, XLPE insulated, copper wire screened, tape armoring, sheathed cables. It shall conform to IEC 60840 latest versions for construction and testing. However different cross section may also be used as required.

- operating voltage: 3.3 kV rms between phase and Ground,
- specified voltage: 1.8/3.0 kV (3.6 kV) rms (according to IEC 60840)

- Copper conductor as per IEC 60228
- b) The PST contractor shall calculate cross section area of the cable as per the required current carrying capacity of transformer with overloading condition and other load requirement and to verify cross-sectional area of these cables as regard to the actual laying arrangement and design data mentioned in respective Para.

The various Constructional features required for the 3.3 kV cables are as under:

Conductor

The conductor shall be formed from circular compact stranded Aluminium class-2 Conductor, as the case may be, complied with IEC latest publications 60228. The conductor shall be compact circular stranded.

> Insulation

The Insulation shall be XLPE, complying with IEC 60502 and IEC 60811. The insulation shall have a higher degree of Cross- Linking, free from contaminants and air voids, heat resistant and shall be applied by the extrusion process.

The XLPE insulation shall be suitable for use on cable in wet and dry locations at conductor temperature as per IEC 60502. For this purpose, short circuit current in conductor is to be considered as 16 kA for 3 seconds. The conductor shall be provided with cross-linked polyethylene (XLPE) insulation applied by extrusion. **The nominal thickness of insulation is specified in the attached GTP and subject to tolerance as per IEC – 60840, clause 10.6.2.**

Water Barrier:

Longitudinal:

The water barrier shall be semi-conducting water swellable tape to be applied over the extruded insulation to block and prevent moisture propagation in a longitudinal direction. The semi-conducting tape shall be suitable for the operating temperature of the cable and compatible with the insulation.

Armouring

Double Tape armouring should be applied over the semi-conducting water swellable tape and the thickness of the same should be as GTP attached. A layer of FRLSZH/FRLS binder tape shall be applied over armour.

Outer Sheath

The outer sheath to be provided as per IEC 60502-1.

4.5.6 Data Sheet- 3.3 kV

Cables As per GTP.

4.6 LOW VOLTAGE CABLES AND WIRING

This specification is made to define the characteristics of low voltage cables used for distribution, control and monitoring. They shall be supplied either in A.C. or in D.C. They shall be used for electrical connection between apparatuses of RSS, TSS, SSP, AMS and ASS.

The general specifications for fiber optic cable is attached as Annexure-A11

4.6.1 General

Conductors supplied for low voltage or remote-control lines shall have a bare or tinned copper core. Semi flexible conductors shall be used; rigid conductors shall be prohibited.

The conductor's cross-section shall be a standard value and shall never exceed 240 mm²; above this value, the appropriate number of conductors shall be connected in parallel. The minimum cross-section of conductors shall not be less than 1.5 sq. mm. **The minimum cross-section of current transformers secondary circuits shall not be less than 6 mm². The minimum cross-section of voltage transformers secondary circuits shall not be less than 4 mm².**

The voltage rating of distribution cables shall be 1100 Volts. Grounding conductors shall have green/yellow-striped insulation. Neutral conductors are to be deemed as being active conductors.

All LV Cables shall be of screened/armored, FRLS type with XLPE insulation. All LV wires shall be FRLS type with PVC Insulation

4.6.2 Cable Cross Section Determination

Determining the technical core section of a cable implies determining the smallest standard cross-section in the type of cable selected which, under the applicable environmental conditions, could satisfy the following criteria:

- (a) Normal temperature rise
- (b) Maximum voltage drops
 - (i) 3% for main distribution lines (between primary and secondary cabinets)
 - (ii) 3% for lighting circuits
 - (iii) 5% for power circuits
 - (iv) 12% for motor circuits during start-up
- (c) Overload and short-circuit
- (d) Protection against indirect contact
- (e) If heavy currents are to be carried, the economic section must also be taken into account.

4.6.3 Standards

All LV & Control Cables shall be screened & armored type as per IS 7098 Pt-1 and IEC60502 Pt-1 in force and shall satisfy the tests given in the above standard:

4.6.4 Identification

All conductors, cables, wiring, terminals and apparatuses shall be identified according to the indications of the diagrams. This identification shall be placed so as to be easily read from the accessible face of the cable or wiring

In all structures, cables shall be marked both at their ends and approximately every 20 meters over their full length, particularly when they change of direction, enter conduits, etc.

Along the track, cables shall be identified in the pulling chambers and at their ends.

The identification shall be realized with Tag-Holder providing the following guarantees:

- Easy fastening,
- Nonflammable,
- Permanence of the marking
- Easy reading.

The tag-holder and its bi-directional marking type shall be submitted to the employers approval.

4.6.5 Connections

All connections, whether made by end-fittings, sleeves or terminals, shall comply with good trade practice. The connection terminal blocks supplied by the PST contractor shall be identified and includes space enabling precise referencing of all terminals, also possessing all guarantees of permanence and fastening.

The crimped section of cables shall be insulated by heat-retractable sleeve. The screen of screened cables shall be connected to ground and continuity shall be ensured.

4.6.6 Fire-Resistant Cables

The cables used for the supply to safety systems or other such area/equipment shall be capable of continuing to feed these systems during a fire. To this end, they shall satisfy the electrical and mechanical integrity when exposed to heat and vibration test defined by UTE standards 32 310 and 32 070, test No 3 (CR1 type) or equivalent. In addition, the PST contractor shall ensure that the insulation and cladding used minimizes the toxicity and opacity of the gasses evolved during combustion. All insulation materials shall be non-hygroscopic.

4.6.7 Cable laying

In general, the cable laying shall comply with the principle of separation between the control and monitoring circuits and the auxiliary circuits of the building (lighting, power, and miscellaneous auxiliaries). The routings and supports of the two circuit networks shall be wholly separated.

Depending on the room gone through and the runs used by the equipment wiring and links, their purpose (supply or distribution of the auxiliary circuit cabinets) or the nature of the specific element concerned (wiring, frame), several different arrangements may be selected to carry the cables and wires, however, in all cases, good care has to be taken to avoid contact between conductors and sharp edges of sheets, iron etc.

Systematically, for control and monitoring cables, all the links of a section shall include 15% spare conductors with at least one spare conductor per cable.

a) Supports**Cable-Ways of Perforated Sheet**

This shall be the normal laying mode of the link conductors. It shall be used systematically along wiring runs necessitating special mechanical protection, precaution or when it is necessary to carry several cable-way levels inside limited space.

Their width shall be defined to enable addition of at least 15% of the number of the cables initially foreseen. In general, when sheets shall be superimposed, the clear heights between one another shall be defined so as to provide perfect accessibility to the cable layers they carry.

All necessary arrangements shall be taken to enable addition or possible replacement of a conductor in a layer and, consequently, to enable its pulling. Several superimposed layers of cables may use the same support sheet but superimposition shall be limited to cables of the same section. If crossings are required between cables or layers coming from different sections, a metal element shall be placed between the layers in way of the crossing. The extent and number of the fastening fittings shall be determined so as to avoid all distortions between rests. The anchoring process of the fittings shall be suited to the supporting element concerned.

Cable-Way on Fittings or Bridges

This arrangement shall be used only for small layers, not justifying the use of slabs. The fittings or bridges shall be sized accounting for possible addition of 15% additional cables.

One independent fitting shall be provided per set of conductors coming from a same section; in no event may conductors coming from different sections be fastened to a common fitting or bridge.

The number of fittings or bridges shall be determined so as to avoid all cable scalloping between fastenings

i. Insulating tubes

When conductors are gathered in strands, they may be laid inside an insulating tube. This solution may be used only for short runs.

ii. Metal Tube

Certain circuits may have to be protected by means of rigid steel tubes or flexible metal tube; all the necessary precautions shall be taken to insulate the fastening so as not to cause contacts between masses of different categories. These metallic tubes shall be properly earthed.

iii. Fastening of Cables and Conductors to their Supports

Fastening of the cables to their supports, whether perforated steel, fittings or bridges, shall be made by means of loosening-proof clamps made of flexible insulating material and by mean of mechanical tightening. If several cables of the same section use a common horizontal run, they shall be able to be gathered and clamped by the same fastening clamp.

Fastening of conductors shall always be provided immediately next to their connection ends. In no event may connection to a terminal block be deemed as being fastening and permanent strain may be exerted on the terminals.

iv. Mechanical Protection of Cables and Conductors

In all cases when the layout of the conductors of bar set of the earthing circuits could render them vulnerable (floor crossings, vertical layers or horizontal crossings through service passages), the necessary mechanical protection for the cables and conductors shall be ensured.

These protections shall show sufficient strength to prevent any damage to the cables and conductors following impacts, which may occur during equipment handling operations; they shall also possess good resistance against corrosion.

For vertical layers, the PST contractor shall ensure supply and installation of sheet casing ensuring efficient protection up to a height of 2 meters above ground. In case of single or limited number of conductors a spare tube shall always be laid. Whenever LV cables or conductors are placed along a run

adjacent to or crossing MV cables, full steel protection on the LV cables shall be provided.

It shall enable possible pulling of the MV cables without risking damaging the insulating material of MV cable. This metal protection shall be connected to the nearest LV earthing collector and shall ensure electrical protection in the event of incident in the MV cable.

4.6.8 Bonding arrangement

Earthing & bonding arrangement for the control cables shall be submitted by the PST contractor for review and approval.

5. EARTHING

5.1 Earth Mesh System

5.1.1 General

The Substation installation is subject to various faults such as operating over voltages, short circuits or lightning. In order to ensure protection to people and equipment, an Earth mesh, sized to limit the step and touch voltages below the dangerous values, shall be provided. The Earth Mesh and installation shall be done in accordance with relevant provisions in standards such as IEEE 80-2000 or latest. Earthing drawing shall be submitted in coordination with civil design & drawings so that during execution minimum infringement of earth mat occurs with cable trenches & other civil structures like pile caps, cable pull pits etc.

Earth network should be designed taking into account conductors' temperature rise as regard to the faulty current levels.

The Receiving Substation (RSS) PST contractor will have to provide a buried earth mesh in the Substation site. As far as the area over which the AMS (Auxiliary Main Substation) & Control Room are situated, earth mat suitably be provided under the building housing the AMS and Control room, apart from the Main Earth Mesh. The Main Earth Mesh shall be done by the RSS PST contractor, taking into account the site conditions (soil resistivity etc.). The soil resistivity of site in dry conditions is to be measured by the PST contractor. In area where soil resistivity is lower than 10 ohm- m, the minimum value of soil resistivity shall be taken as 10 ohm-m.

In areas where the soil resistivity is rather high and where it may not be possible to obtain a low impedance grounding system by spreading the grid electrodes over a large area, as is done in more favorable conditions, the various measures given in latest IEEE 80 shall be used for reducing the soil resistivity so as to meet the site constraints. The Main Earth mesh has to be linked (**by exothermic welding**), by means of two copper cables / flats of appropriate size as given in Clause 5.11 to the following:

- the earth mat under the AMS room
- the buried rail/connecting strip for traction return current
- Auxiliary Main Transformer neutrals
- All equipment structures supporting equipment
- Baffle walls between transformers.
- Lightning protection Earthing

The connections which are prone to bi-metallic action shall always be done through bimetallic strips and washers.

5.1.2 Parameters affecting the design of earth mat

Several variable factors are involved in the design of an Earth Mat at Substations. The following are some of the parameters which affect the design of Earth mat.

- Magnitude of fault current
- Duration of fault
- Soil resistivity

- Resistivity of surface material
- Earthing mat geometry
- Material of earth mat conductor
- Shock duration etc.

The Earth mat has to be designed for the site conditions and shall ensure a low over all impedance (not more than 0.5 ohms) and a current carrying capacity consistent with the fault current magnitude.

5.1.3 Short Circuit Level

The maximum short circuit power (Isc), considered for the whole substation area, for different voltage levels, are as follow:

> For 220 kV	7200 MVA
> For 66 kV	7200 MVA

5.1.4 Short Circuit Current

Accordingly, the short circuit current (as per CEA regulations-2010) to be taken into consideration, for the Earth mesh design at Substations, shall be as follows:

> For 220kV	31.5 kA for 1sec.
> For 66kV	31.5 kA for 1 sec

5.1.5 Duration of fault current

In India, the short-term rating of most of the equipment is based on 1.0 second duration of fault. Therefore, 1 second may be adopted on the duration of fault in the calculations to determine the size of conductor for the earth mat. For the purpose of determining the safe step and mesh potentials, duration of 0.5 second may be adopted. However, it has to be ensured that, on the basis of the protective gear and protective scheme provided, the fault is cleared within a period not exceeding 0.5 seconds.

5.1.6 Determining the max Grid current (IG)

The design value of the maximum grid current IG is given by the following formula

$$I_G = C_P \cdot D_f \cdot I_g$$

Where,

IG = Maximum grid current in Amperes

CP = Corrective projection factor

Df = Decrement factor

Ig = Symmetrical grid current (RMS) in A

Ig= Sf (3IO)

Where,

I_0 = Zero Sequence fault current

S_f = Current division factor (which relates to the magnitude of the portion of fault current to that of its portion flowing between the earth mat and surrounding earth, to the total fault current)

The calculation of S_f is done by deriving an equivalent representation of the overhead ground wires, neutrals etc, connected to the Earth mat and then solving the equivalent circuits to determine the fraction of the total fault currents which flow between the mat and the earth and through the ground wire or neutrals. In practice, it will be fairly accurate to adopt a value of 0.5 for S_f to determine the fault current that flows through the grid to earth.

Hence, the values of maximum grid current I_G to be considered for Earth mat for Substations of different voltage levels, may be taken as follows:

For

220 kV	$0.5 \times 31.5 = 15.75 \text{ kA} \approx 16 \text{ kA}$
66 kV	$0.5 \times 31.5 = 15.75 \text{ kA} \approx 16 \text{ kA}$

Important Note: The above values of max grid current are applicable only for determining the estimated values of Step and Mesh potentials. For determining the cross-sectional area of the Earth mat conductor, full fault current should be considered.

5.2 Exothermic Welding

Suitable sample of molds for each type of joints / connections shall be submitted to BSTP for approval. Exothermic welding shall comply with IEEE 837 and UL 467.

The resistance of the joint shall be tested on a random sample. Method statement clearly indicating various procedures, precautions required for an effective welding shall be submitted by the PST contractor for approval.

5.3 List of Reference Standards

Latest edition of all the standards applicable at the time of submission of design shall be complied:

IEEE 80

IS 3043

CBIP manual on earthing

5.4 Earth Mesh Characteristics

5.4.1 General Design

A mesh made of bare cables/ copper rods; copper strips joined by exothermic welding forms the protection earth circuit.

Earth conductors should be buried as deep as possible to keep a significant cylindrical equipotential area ensuring the earth resistance decreasing. The common practice consists of to bury the mesh at 1m depth, to avoid soil conductivity variation as regard to the variation of dryness or humidity conditions.

The connection on power equipment should be made by conductors in loop mode avoiding the power equipment insulation from the earth mesh in case of conductor breaking. The earth connection to equipment in antenna mode is strictly prohibited. Earth conductors should preferably be cylindrical copper cables/flats. Earth conductors are linked by fixed connection. The earth mesh implementation should avoid any permanent or occasional contact of earth conductors with other different metals.

5.4.2 Particular Arrangement to Minimize Voltage Rise

The ground is considered as a pure resistance regarding electrical phenomenon. Only very bad resistivity conjugated with very high frequencies involves the ground capacitive parameter. To minimize electromagnetic coupling between Low voltage cables and HV equipment, the cables shall be annealed types earthed at each end.

In the aim to:

- Decrease the loop length given by cable shielding and the earth,
- Limit the current in these shields in case of short circuit,
- Minimize the works,

The earth conductors may be buried as far as possible under the LV cable routing. The distance between LV cables and earth conductors shall be 0.30 m. at minimum to avoid any impact on LV cables in case of earth conductor overheating. The earth mesh density shall be increased around circuit breaker and power transformer cells.

5.5 Equipment connecting mode to Earth mesh

5.5.1 Principles

Copper conductors/strips of suitable size joined by exothermic welding technique form the Main Earth mesh. Main gantries, frames, equipment bodies or tank and all metallic structures are to be connected minimum two locations on an uninterruptible loop of the earth mesh.

The earth electrode (with chamber) shall be 40mm dia copper perforated pipe of 3m length shall be provided with proper size of earth chamber not less than 450mm x 450mm x 450mm, salt & charcoal and test link to measure the value of electrode as per IS 3043 for connection of various equipment as specified in the specification.

A clamp makes the connection point with bi-metallic sheet plate located close to the soil from which aerial earth cables linking the equipment will be connected and crimped on earth mesh. When one clamp is not enough, it could be provided a copper connecting strip on which several clamps could be installed.

All of conductors linking an equipment to the earth and liable to support the short circuit current shall have the same cross section as the earth mesh conductors. When the equipment connection is only made for equipotential purpose, the cable cross section could be less

than earth mesh conductor with a minimum of 25 mm². Proper tagging on earth strip ends (equipment or earth pit end), should be done and reflected in layout plans.

5.5.2 Earth Cable Fixations along the Structures

All cables should be fixed all along the masts and beams as follows:

- Bare cables should keep distance from the metallic supporting structure to avoid any

electrolytic corrosion and should be fixed via metallic (i.e. bronze or copper alloy) bolted clamp with bi-metallic sheet plate.

- Insulated cables shall be fixed to the structure in the same manner as above when earth connection with the structure is necessary, or by collars mainly used on catenary masts.

5.5.3 Equipment Connection

a) *Measuring Transformers*

Voltage Transformers:

To reduce high frequency interference transmission at the secondary side; the P2 terminal (cold point) of primary winding, located inside the transformer connection box is connected to the earth mesh at the general earth connection level.

Current Transformers

The S2 terminal of secondary winding should be connected to the earth mesh, with a connection as short as possible.

b) *Circuit breakers*

Earthing of CB could be ensured through the supporting frame, itself connected to the earth, except when one part of the equipment is painted. In this case it is necessary to install an earth cable. In the first case a copper cable shall jump the mechanical connection between the CB and the frame.

For circuit breakers two earth clamps on each side of the frame base and linked to the earth mesh should be implemented.

c) *Power Transformers*

Each file of running rails (if any) and rollers shall be earthed directly. The tank insulated from the rails is earthed using a low insulated cable via the protection current transformer The S2 current transformer terminal and metallic base shall be earthed via a separated connection. The power transformers earth cable should be as shorter as possible.

The each of four panel of auxiliary transformer cover shall be connected to the earthing system at minimum two locations by cu strip of 25 x 5 sq. mm.

c) *Neutrals*

Two separate and distinct earth pits with chambers and connected to main earth mat shall be provided for all the transformer neutrals

d) *Isolators*

Incoming isolators earth blades should be linked to the isolator base by copper braid, the base being directly connected to the mesh. Electrical control boxes should be earthed directly. On hand operated isolators a copper braid should link the control box with the transmission axle, the control box being directly connected to the mesh. In both control modes; a metallic duck board should be installed in front of the control device, linked to the control boxes and the mesh via a direct connection fixed on the frame.

e) Lightning Arresters

The lightning arrester earth terminal shall be directly connected to an earth electrode formed from a separated earth pit (with chamber) and also connected to the earth mesh. The Earth Pit of LA should be located at the nearest distance to LA, and strip of minimum length with minimum bends should be provided for connection.

f) Earth Gantry Arrangement

In case of gantry arrangement with tower and beam, An ACSR conductor of suitable size (min. 93.3 sq.mm.) will run continuously through each beam and towers clamped at suitable interval and earthed to the general mesh by mean of bimetallic connection.

h) Lightning Guard Line Earthing

Lightning guard line if provided shall be earthed through 93.3mm² steel bare cable to a specific earth Electrode located at the bottom of each guard line supporting structure, these earth Electrode being connected to the general earth mesh at the RSS-cum-TSS.

The connection of panels containing low voltage electronic equipment like SAS, Relays, PC etc. to be done suitably as per recommendations of manufacturers of these items with a confirmation from them that such earthing connection will not interface in the proper functioning of these devices. If required by manufacturers of these items, a separate earthing system to be installed by separate earth electrodes for these devices, panels etc.

5.6 AMS & Control Room Building Earthing

Before laying the foundations of the RSS Building, a well interconnected Earthing mesh using 120 Sq-mm bare copper flexible conductors will be laid (buried conductors under the foundation raft). These copper bare flexible conductors will be taken up to plinth beam and connected to main grid with exothermic welding to ensure proper connections at minimum two locations on each face of building. The copper bare conductor will be clamped or welded to column bar.

The main Earth Mat placed in the switchyard shall be extended to the building area also and risers to be taken for equipment placed inside the building. However, Earthing in GIS room shall be provided as per GIS manufacturer recommendation and connected to main earth mat.

5.7 Gas Insulated Switchgear (GIS)

Earthing requirement of GIS installations are similar to air insulated substation (AIS), i.e. safety of the operating staff against any hazard and protection of equipment against electromagnetic interference and damage. The area occupied by a GIS is typically 10-25% of that of AIS equipment. Therefore, achieving the required Earth Potential Rise (EPR) or the earth resistance of grid earth electrode is more challenging task. Earthing of all GIS equipment shall be done as per recommendation of GIS manufacturer and calculations shall be submitted in support of dangerous voltages (touch, step voltages etc.) & grid resistance as per latest IEEE standard 80. Manufacturer's representative shall be involved during

installation of earth mat to certify that the earthing of GIS has been done as per manufacturer's recommendations.

5.8 5.8 Boundary Wall Earthing

Earthing of boundary wall/fencing can be achieved by placement of boundary wall outside the grid area by 2 m with no electric bonding between fence and main station grid. Separate earthing shall be done for boundary wall which is not connected to main earth mat. 25 x 5 mm GI earth strip is running continuously along the boundary wall/fence, and it is connected to fence at every 02m and also with at least 4 numbers of separate earth electrode with salt and charcoal of 40mm dia, 3-meter-long perforated GI pipe with test link and earth chamber at each corner of site (not connected to main earth mat).

If the site constraint (space, area availability etc.) doesn't allow above design, then suitable earthing design of boundary wall / fence shall be submitted as per latest IEEE 80.

5.9 5.9 Solar Panel Earthing

Wherever roof top solar panel are provided in the RSS to promote use of renewable energy and reduce electricity consumption. To meet the earthing requirement of solar system at least two separate earth pits with charcoal and salt of 40mm dia, 3-meter-long perforated CU pipe with test link and earth chamber shall be provided.

5.10 5.10 Lightning Protection

Lightning flashes to earth may be hazardous to structures and to services. The hazard to a structure can results in

- damage to the structure and to its contents,
- failure of associated electrical and electronic systems,
- injury to living beings in or close to the structure.

Consequential effects of the damage and failures may be extended to the surroundings of the structure or may involve its environment. The hazard to services can result in:-

- damage to the service itself,
- failure of associated electrical and electronic equipment.

To reduce the loss due to lightning, protection measures may be required. Whether they are needed, and to what extent, should be determined by risk assessment. The risk of the probable average annual loss in a structure and in a service due to lightning flashes, depends on:

- the annual number of lightning flashes influencing the structure and the service
- the probability of damage by one of the influencing lightning flashes
- the mean amount of consequential loss.

Lightning flashes influencing the structure & service may be divided into

- flashes terminating on the structure/service,
- flashes terminating near the structure/service,

Flashes to the structure or a connected service may cause physical damage and life hazards. Flashes near the structure or service as well as flashes to the structure or service may cause failure of electrical and electronic systems due to over voltages resulting from resistive and inductive coupling of these systems with the lightning current. Moreover, failures caused by lightning over voltages in users installations and in power supply lines may also generate switching type over voltages in the installations.

The number of lightning flashes influencing the structure and the services depends on the dimensions and the characteristics of the structure and of the services, on the environment characteristics of the structure and the services, as well as on lightning ground flash density in the region where the structure and the services are located.

The entire Substation shall be protected against lightning by providing either earth screen conductors on tower peaks, or by means of Lightning Protection masts suitably spaced to cover the entire area and assessment of risk etc. shall be carried out using IS/IEC 62305 or latest.

5.11 5.11 Size of Earth Mat Conductor:

The tentative min. size of copper earth mat shall be as follows:

Voltage	Fault Current	Area of Conductor (Sq	Size of Earth Strip
66	31.5	114 mm ²	25x5
110/220	31.5	114 mm ²	25x5
220	40	144 mm ²	30x5

5.12 5.12 Testing of Earthing System / Pits

- Earth mat laying photographs shall be submitted to BSBRP before backfilling so that the same can be utilized for future reference if required.
- All Earth pits shall be treated pits as per IS 3043 with provision of watering/ perforated pipe. The resistance of individual earth pit shall not be more than 5 ohm for normal soil and 10 ohm for rocky soil.
- The resistance values of all the earth pits shall be measured and recorded along with the date of measurement.
- The location of earth pits shall be clearly marked in the drawings and it should be identifiable during maintenance.
- Test link shall be provided for measuring the resistances of earth pits.
- Test certificates of all the materials used in earthing shall be submitted to BSBRP.
- A typical drawing showing details of gantry/ structure earthing shall be submitted separately to BSBRP
- The PST contractor shall appoint third party auditor under the scope of this contract to carryout comprehensive earthing adequacy audit of the entire substation grounding system to determine the effectiveness of the earthing system. Comprehensive Audit shall be carried out during commissioning and again before end of Defect liability period (DLP), brief scope of Audit is given in Annexure 16. The detailed scope of work and Test methodology shall be prepared by the auditor and submitted for approval of employer. Any additional test or test method suggested by the employer shall also be included in the audit without any additional cost to employer.

a) O&M documentation

For each RSS, PST contractor shall prepare an O&M maintenance manual for earthing system comprising detail record of soil resistivity, calculation, earth grid / electrode resistance measurement, As built drawings, etc. As built Earthing Layout plan shall be displayed in the RSS.

6. METERING

6.1 GENERAL

The following metering arrangements shall be provided at the Receiving Substations. All energy meters shall be as per latest CEA regulation.

6.2.1 On the Incoming Feeders from the Power Supply Authority

- Ammeters (to read the value of current in each phase of each of the Incoming Feeders)
- Voltmeter (to read the value of line voltages R-Y, Y-B, B-R, in each of the Incoming Feeders)
- Energy meter (Electronic energy meter, Accuracy class 0.2s, corresponding CT secondary core shall also be of 0.2S class to enable measurement of Active energy (kWh), Reactive energy (kVARh), Apparent energy (kVAh), frequency, power factor, instantaneous maximum demand(Power),integrated maximum demand, total harmonic distortion with ABT (Availability Based Tariff) features etc. . Energy meter should have the feature of downloading data, showing the customized Time of Day (TOD) report of last month and Maximum demand on the selectable time basis (15 min, 30 min, 01 Hours etc).There should be provision of communication port in energy meter, so that Maximum demand and Integrated Demand of every 15min / 30min can be monitored online from SCADA. One Energy meter on each incoming feeder is required to be provided, which shall be able to indicate/record/store the energy of the incoming feeder, through suitable connections. Meters should match tariff scheme (TOD) and Energy Meter application S/W (for remote metering etc. if applicable) shall also be as per requirement of particular state. Meters shall also be suitable for open access as well. Meters shall also be suitable for open access requirement as well.

6.2.2 On the Traction Transformer Output side and Depot Feeder

- Ammeters (to read the value of current delivered by each Traction Transformer)
- Voltmeter (to read the value of secondary voltage of each Transformer, whether on-load or as hot standby)
- Energy meter (Electronic energy meter, Accuracy class 0.2s, to enable measurement of kWh, kVAh, kVARh instantaneous maximum demand kVA and total harmonic distortion. One energy meter with summation CT is required to be provided, which shall
- be able to indicate/record/store the values of energy (kWh) and max demand (kVA), delivered by the Traction Transformer, through suitable connections)
- Energy meter (Electronic energy meter, Accuracy class 0.2s, to enable measurement of kWh, kVAh, kVARh instantaneous maximum demand kVA and total harmonic distortion. To measure the energy consumed by depot feeder whenever applicable

6.2.3 On the AMS Transformer Output side

- Ammeters (to read the value of current delivered by each AMS Transformer)
- Voltmeter (to read the value of secondary voltage of each Transformer, whether on-load or as hot standby)
- Energy meter (Electronic energy meter, Accuracy class 0.2s, to enable measurement of kWh, kVAh, kVARh instantaneous maximum demand kVA and total harmonic distortion. One energy meter with summation CT is required to be provided, which shall be able to indicate/record/store the values of energy (kWh) and max demand (kVA), delivered by the Auxiliary Main Traction Transformers, through suitable connections).

6.2.4 Communication to RSS and OCC

All the metering data inclusive of above parameters shall be transmitted/ communicated to SAS in RSS and also to SCADA in OCC through OFC medium for trends and reports.

6.2.5 Testing of Energy Meters.

All the energy meters should be tested & calibrated by the accredited laboratory. PST contractor must submit the testing & calibration certificate for Energy Meters in this regard. All energy meters mentioned above shall be same type and record the reading for lag only power factor.

Online Energy Monitoring: shall be provided for all voltage levels of RSS 220/220/66 kV, 33kV, 25kV, 415V energy meters shall be installed on all I/C feeders and data shall be collected and displayed, on one common software application, on web browser. One local PC shall be provided by PST contractor for online energy monitoring

7. GENERAL ELECTRICAL WORKS

7.1 Yard Lighting

The lighting of the RSS cum TSS shall be provided to permit circulation in the external area comprising the RSS and the TSS. A lighting coverage of 30 lux at 1 metre from ground level shall be ensured for the entire RSS-cum-AMS-cum-TSS compound.

This lighting shall be installed on the main masts, over the conductors, with adequate electrical clearance. The masts, structures, beams used for hanging conductors should not be used for fixing lighting fixtures, to avoid shutdown of switchyard and supply during maintenance of lighting fixtures. This distance shall be at least 3 meters from the conductors but not less than the safe working clearance permitted by relevant safety rules and codes in India.

When the mast is inside the area, each face of the mast shall be fitted with one lamp. When the mast is at one border, only the 3 or the two sides of the mast, facing into the area, need to be fitted with one lamp each. The complete lighting fixture shall be type tested as per IS 10322(5) and shall have an IP code of 65 to ensure a good protection against dust and water (raining).

LED Light to be provided to have a suitable power to ensure the required level of illumination specified above. Colour temperature will be 4000/5500 K. The life duration shall be at least 50000 hours. The external yard lighting shall be provided with timer control

7.2 Lightning Protection

The entire Substation shall be protected against lightning by providing either earth screen conductors on tower peaks, or by means of Lightning Protection Masts, suitably spaced to cover the entire area. The Lightning Mast shall be type tested as per LM-79. Type Test certificate for LM Bolts as per relevant standard shall also be submitted for approval.

The height and locations of Lightning Masts shall be designed appropriately, with due consideration to the equipment layout in the RSS, to ensure that all the equipment meant to be protected against lightning are within protective zone provided by the Lightning conductor. The Lightning conductor generally consists of:

- the lightning receiver projecting above the object to be protected
- the earthing grid, and
- the conductor which connects the receiver with the earthing grid and is meant to carry the lightning current away safely to ground.

The PST contractor shall indicate the heights and locations of the Lightning Masts, on the Substation Layout Drawing, and shall also submit supporting design calculations to prove the adequacy of the arrangement to cover all equipment for protection against lightning.

8. CIVIL WORKS

8.1 General

Unless stated otherwise in the Contract Documents the whole of the civil, structural, services and finishing works shall be constructed to comply with relevant laws and regulations of the Indian Government and of Bengaluru state government as well as complying with the requirements of the Bengaluru Public Utility Authorities, fire regulations and such additional requirements as may be stated in the documents. The design requirements relating to fire safety and escape shall be generally in accordance with NFPA, BS 476 and other applicable standards. The PST contractor will be required to execute civil works at the RSS-cum-TSS-cum-AMS locations. PST contractor shall conduct Soil test /geo technical investigation for consideration of ground improvement works and the report of the same shall be submitted for employer/engineer approval. The entire substation including control room along-with electrical items are to be accommodated in this area. The building shall fully comply with all the statutory requirements. It shall also fulfil CEA guidelines. Civil design shall comply with the stringent requirements as per environment condition as given in IS 456 and relevant RDSO specifications.

The specific nature of civil works, required to be done at different locations, will be different and will depend upon the locations. Broadly, at every RSS, TSS and AMS locations, where no other civil PST contractor is working, the PST contractor will be required to arrange for land preparation, erection of boundary wall, entrance gate, baffle walls between transformers transformer support anchor blocks, provide architectural services, civil and structural design services and other auxiliary services like water supply, lighting, ventilation, air-conditioning, fire detection and alarm etc, for the AMS and Control Room Building. The services to be provided by the PST contractor are broadly described in the subsequent paragraphs.

The grade of concrete should be as per approved design but not inferior to M-30 as per IS 456 for all civil construction in RSS.

All necessary steps shall have to be taken by the PST contractor and requirements fulfilled so as to obtain the green building Certification (IGBC certification with Platinum rating) for RSS

building. The equipment, process, design shall be meeting these requirements and is in the scope of contract and included in bid. All electrical items shall generally be of 5 star rating as per BEE

The PST contractor shall submit a list of civil structure and architecture drawing along with tentative submission plan before submitting first set of drawings. The PST contractor shall take specific approval from engineer/employer before engaging sub-PST contractor. Accordingly, the drawing submission shall be planned.

The PST contractor shall use allowed recycled material in civil construction of RSS building to get platinum IGBC rating. Wet Land type Sewage Treatment Plant shall be provided subject to the approval of the Engineer-in-Charge.

All preparation of documentation for IGBC certification for RSS is in the scope of RSS PST contractor (Check list for IGBC is enclosed as annexure- A1C)

Site Facilities

The PST contractor shall provide and maintain its own site accommodation at locations consented to by the Engineer. Offices, sheds, stores, mess rooms, garages, workshops, latrines and other accommodation on the site shall be maintained in a clean, stable and secure condition. Living accommodation shall not be provided on the site. The PST contractor shall comply with the requirements of Chapter-15 to the Employer's requirements- General Specifications. In addition, PST contractor shall provide and maintain field offices for use of BSTP staff during the contract period at each RSS location of area not less than 30 sqm with toilet & electricity facility including services for office upkeep, consumables, furniture, security etc. PST contractor shall also be required to install adequate number of video cameras (duly covering the entire site area) at each working site under construction. The provision shall also be made to provide the live streaming of video cameras at the Engineer's premises to facilitate the Engineer to monitor the site progress on a daily basis. There shall be provision for recording of CCTV stream for at least 1 months and automatic deletion shall be based on FIFO after 1 month only. The BSTP shall be administrator for control of CCTV system.

8.2 Land Preparation

The Bidder is advised to inspect the sites for various RSS-cum-TSS-cum-AMS locations and gather for himself various details such as topography and land levels, soil condition including the safe bearing capacity, soil resistivity etc, HFL (highest flood level) at the Substation site, drainage requirements etc, in order to ensure that the work content is fully appreciated by him at the time of preparation of bid.

The site will have to be cleared of all existing encumbrances, leveled and compacted. The finished ground level of the Substation site shall be above the Highest Flood Level (HFL) in the Region, to be ascertained by the PST contractor and confirmed by the Local Authorities. In any case, the finished ground level shall be at least 60 cm above the main rail/ road level, near to the site. The compaction of soil shall be done in accordance with Standard Engineering practices and the site, after compaction shall be fit, without any detriment to support the heavy equipment, including transformers whose weight may be in the region of 100-110 tons, supported on 4 wheels which are spaced approximately 2.4 meters, running on a Broad Gauge (1.676m) track. During land preparation, if it becomes necessary to cut or transplant trees, it shall be done by the PST contractor with the permission of Forest authorities/relevant authorities and with the approval of BSBRP, strictly in accordance with the Local laws.

Efforts shall be made to transplant tree instead of cutting to the designated location, the PST contractor shall appoint tree transplanting expert for the same. Cutting of tree shall only be done after exhausting all efforts for transplanting of trees.

8.3 Access Roads / Rail cum Road / RCC Road

The PST contractor will be required to provide suitable access road to the Substation site, from the nearest main road, which has the necessary width and strength to carry the Power Supply equipment. The Access Road, Rail-cum-Road in the transformer area and other Approach Road to Building & Storeroom inside the RSS shall be of RCC as per BSTP specifications.

For this purpose, the PST contractor shall prepare the necessary design and calculations and submit them to the Employer/Employer's Representative, for approval. On approval of designs and calculations, the PST contractor shall construct the approach roads as per approved designs. The approach roads should, at the minimum, be 5.0m wide and shall be able to support 100 – ton trailers.

Note:

The details of the approach road will be shared with the successful bidder during detail engineering.

8.4 Drainage

Drainage of the Substation site shall be provided as per the best engineering practices, so as to prevent surface flooding and pooling of water. For this purpose, suitably designed drains and sumps shall be provided and if the water level inside the sump rises above a predetermined

level, the sump water shall be arranged to be evacuated by means of suitable electric pumps fixed in the sump. In addition, suitable precautions shall also be taken to prevent transformer insulating oil from being discharged into the environment in the event of a ruptured transformer tank. This shall be realized by a retention tank for each transformer

- dimensioned in order to be able to contain the whole transformer oil
- laid below the transformer
- covered by a net/grating to maintain a 5 cm width stone bed on which the oil might fall
- fitted with a beside extraction pit to be used for oil or raining water pumping.

The pumping shall be realized with a portable manual or electrical pump, which is to be stored in the maintenance room. The drainage system of RSS shall be connected to the local drainage system of the city by the RSS PST contractor with the permission of local authorities and it should be suitably protected to ensure prevention of back flow of outside drainage water to RSS.

8.5 RSS Building (Indoor GIS, AMS& Control Room Building)

8.5.1

The RSS PST contractor shall submit the General Layout for approval of the multistoried Control Room Building to accommodate all equipment required for completion of RSS work as per the National Building code of India. Working space shall be allotted if available during construction. The structure shall be of RCC framed structure based on BIS codes. Based on this, the PST contractor will be required to prepare and submit detailed design of civil, structural, architectural and electrical works. All applicable building regulations must be observed, and also the rules for good building practice. After obtaining the Employer's/ Employer's representative's approval, the PST contractor will construct the building along with auxiliary works, in accordance with approved drawings and designs.

All drawings, designs, calculations, etc. shall be reviewed and certified by DDC appointed by Employer.

8.5.2 Civil and Structural Design

The PST contractor shall perform the civil and structural design, including the preparation of calculations, drawings, specifications, cost estimates and other documents, for but not limited to:

- General arrangement (layout and elevation)
- Structures and sub-structures
- Foundations
- Drainage (Covered type)
- Networks (Water, sewage, etc.)
- Baffle walls
- Boundary walls.
- Earthquake resistance as per zone of Bengaluru

8.5.3 Architectural Services

The PST contractor shall perform the Architectural services design, including the preparation of calculations, drawings, specifications, cost estimates and other documents, for but not limited to:

- General arrangement (layout and elevation)
- Section and details
- Walls, floors, ceiling finishing
- Doors, frames and windows
- Toilet rooms, and partitions including equipment
- Concrete (types and treatments)
- Thermal and moisture protection
- Electrical and mechanical fittings

- Building surrounding environmental arrangement

The standard of architectural work should be of the same level as existing for other surrounding buildings of BSBRP.

8.5.4 Auxiliary Services

The PST contractor shall provide and perform the Auxiliary service design, including the preparation of calculations, drawings, specifications, other documents, for but not limited to:

- Lighting, fans and sockets
- Ventilation and air conditioning as per specification attached as Annexure-4
- Fire alarm and detection as per specification attached as Annexure-A6
- Cables routing (cable trenches, trough, trays etc.)
- False ceiling and raised floor with foam concrete in control room with Antistatic flooring
- Earthing
- Water pumps
- CO2 sensor as per IGBC requirement

8.5.5 Design Quality Control Plan and Design services

The PST contractor shall prepare and submit a Design Quality Control Plan to the Employer's Representative and perform the Design Services in accordance with the Design Quality Control Plan. The PST contractor shall be responsible for the correctness and technical merits of his design, calculation, drawings, specifications and all other documentation.

All documents shall be delivered, submitted and approved by the Employer's representative prior to start the construction work. For each submission the PST contractor will submit an original, 3 copies and the editable electronic file.

8.5.6 RSS BUILDING: (Indoor GIS, AMS & Control Room Building)

Requirements a. General

While planning and constructing the buildings and rooms for electrical equipment, care must be taken to ensure that:-

- All operational requirements are satisfied
- the rooms are free from groundwater and flooding.
- Brickwork below plinth beam to NGL / Tie-beam shall be provided for proper protection of soil erosion/ settlement.
- Adequate accesses are provided for operation, transport and fire-fighting services all applicable building regulations are respected the building is structurally and functionally adequate in all respects and aesthetically presents a good look.
- The cable cellar is to be provided for GIS Building at ground level.

Materials used for the construction of the building shall be new and of good quality. Materials shall be so chosen that the buildings when erected shall have good heat and sound insulation properties in normal conditions, as well as when combined with the heating or air-conditioning equipment installed by the PST contractor. Height of the control room and AMS room shall be at least 4.8 mt. and that of the GIS room shall be at least 6.5 mts. All transformers, with all safety requirements, shall be inside building with one side open towards approach road/access road/main road.

b. Walls, Ceiling & Floors

Walls, ceiling and floors must be dry. Both external and internal walls shall be soundproof and 2 hours fire proof. The walls of oil type transformer area shall be 04-hour fire rated. Means of proper exit / evacuation shall also be planned. The inside surfaces of the walls should be as smooth as possible to prevent dust deposits.

The ceiling shall be finished in such a way that the equipment is not endangered by falling plaster. The floor surface must be easy to clean, pressure-resistant, non-slip and wear-resistant. Concrete floor with adequate strength to withstand movement of equipment/panels wear-resistant protective coating with ceramic tiles (non-skidding type) is recommended for the control room.

False floor / raised floor with foam concrete with anti-static flooring and inbuilt trench and false ceiling may also be provided as per design in control room as per Employer's requirement. Attention must be paid to floor loadings when taking the equipment in and out. In front of control panels and Switchgear panels, insulated mats of approved design, shall be provided. The internal walls & ceiling shall be finished with plastic emulsion in control room and oil bound distemper in other rooms.

In staircase granite shall be used. The handrail of staircase shall be of stainless steel. All bricks to be used in RSS shall be of average compressive strength 100kg/cm² and conforming to that required for green building/IGBC certification. All floors shall be provided with epoxy coating and this shall be up to the satisfaction of the engineer in-charge.

c. Doors and Windows

Windows to each room shall be of an area, not less than 50% of the floor area. Windows must be so arranged that they can be opened and closed without any personnel coming dangerously close to any live parts. All windows of the ground floor building shall be fitted with burglar bars firmly attached to the structure of the building. The window shall be aluminum section of thickness not less than 5mm with powder coated min thickness 80 microns.

External doors shall have barrel bolts both at top and bottom of one leaf and a Yale lock on the other leaf, they shall be equipped with an Anti-Panic system permitting urgent door opening by means of a bar located at 0.7 m high from floor level.

Emergency fire exit doors with panic bars should be provided in AMS control room building and shall be accordingly marked. External doors shall be of solid external quality and hung with heavy-duty hinges.

d. Staircase:

structurally shall be of RCC type, width, length and risers should be as per NBC and shall be covered with granite suitable color and quality as per approved by engineer in charge.

Staircase shall be provided with good quality of Stainless steel (SS) hand rails.

Plinth protection shall be provided of good aesthetic appearance with granite.

e. Air Conditioning

The rooms must be sufficiently ventilated. In the control room, where people are likely to be present constantly, the following indoor climatic parameters should be possible to be maintained.

Temperature - 22°C Minimum & 26°C Maximum

Humidity - 60% Maximum

The control room should be provided with split type AC as per the requirement to achieve above results. Number of outdoor and Indoor unit shall be N+1 configuration where N- working unit as per heat load calculation and one unit standby in each. The maximum ambient temperature inside the room, averaged over 24 hours shall not exceed 35°C.

8.5.7 Battery Rooms

In battery rooms, the following additional precautions have to be taken.

- the walls & floor must be resistant to electrolyte action and provided with acid resistant tiles.
- ceilings should be painted with acid-resistant paint which does not give off harmful vapor.
- Ventilation by means of induced draught is preferred. An air change rate of 5 times the room volume per hour is recommended.
- The battery rooms shall be fitted with eye washer equipment.

8.5.8 Water Supply, Electricity, Pantry, Sanitation and Fire Fighting

Building shall be supplied with continuous (24 hour) running potable cold water to the pantry and washrooms. One reverse osmosis (RO) water cleaning plant of suitable capacity (suitable storage of at least 30 ltrs) with cooling facility for drinking water shall be provided in the RSS.

A small pantry with adequate size and provision of the ventilation, power sockets shall be provided in the control room building. The location shall be strategically selected to avoid any heat in flow to the air-conditioned room.

A bore well of suitable capacity shall be provided with permission of local authorities in the RSS for water requirement. Rainwater Harvesting should be provided in RSS. The toilets may use raw water for flushing, shall be equipped with water closets and sitting type stools and urinal pot with sensor and shall be adequately ventilated through the ceiling.

The PST contractor shall also design and provide necessary arrangements for the constant and hygienic disposal of all effluent, sewage and rubbish from the buildings to the nearest sewer

line or septic tank. Wetland water type treatment plant for sewage treatment should be provided with suitable size of pumps for feeding water to tank. Water meter in the water pipe line for fresh water as well as raw water to be provided. Storage and septic tanks shall be required due to restricted hours of water supply in the Bengaluru Area. UG Water tank capacity of 2 KL to be considered. Septic tank details shall be finalised during detailed

engineering stage.

All buildings shall be supplied with electricity at 240 volts, at 50 Hz. Firefighting equipment shall be provided in accordance with the recommendations of the Bengaluru City Fire Brigade.

8.5.9 Exterior Finish

External finish of the Control Room Building shall be attractive and pleasing to the eye by using of an indigenous combination of glass and exterior texture finish, subject to Employer's approval. Considering that the RSS locations and AMS and Control Room Buildings are prestigious installations and should blend smoothly and aesthetically with the surroundings, the AMS and Control Room Building shall have a good exterior finish.

8.5.10 Internal Equipment

The AMS and control room building shall be as per design and constructed to accommodate the following equipment and facilities:

1) Power Equipment Room

- 33 kV switchgear
- Low voltage auxiliary transformers 33 kV / 415-240 V
- Low voltage distribution cubicles (AC and DC)
- Battery chargers
- Reactive power compensation device (STATCOM) along with Transformer

2) Battery Room

- Batteries

3) Control Rooms

- Control and Relay panels
- SCADA equipment, including workstations
- SCADA system
- Space for BCC system

4) Rest Room and Toilets

5) Maintenance Room

The building shall have sufficient room to accommodate above equipment and requirements and cellar in case of GIS with all partition walls, openings, and all facilities, designed to receive power supply installations. Facilities should include but not restricted to:

- Water; network and equipment (supply, sanitary, sewage...)
- Cables trenches and conduits
- Low voltage installation (lighting socket, fans, ventilation, fire protection...)

- Doors and locks
- Painting

8.5.11 Low Voltage Installation

1. Lighting & Power

Normal Lighting and Power Supplies

The lighting and power auxiliary outgoings located in AC auxiliary cubicles, forming the exit point for all the normal lighting supplies and power connections, shall be supplied from both LT auxiliary transformers. The lighting and power supplies shall be distributed as follow:

a) AC Auxiliary Cubicle 1:

- The first half lighting of the AMS power equipment room
- The first half lighting of the external RSS (e.g. yard/equipment lighting etc.).
- The external yard lighting shall be provided with timer control.
- The first half lighting of the external TSS (e.g. yard/equipment lighting etc.).
- The external yard lighting shall be provided with timer control.
- The lighting of rest room and toilets
- The lighting of control room
- The supply of sockets in the AMS
- The supply of sockets in control room
- The supply of sockets in TSS

b) AC Auxiliary Cubicle 2:

- The second half lighting of the AMS power equipment room
- The second half lighting of the external RSS (e.g. yard/equipment lighting etc.).
- The external yard lighting shall be provided with timer control.
- The second half lighting of the external TSS (e.g. yard/equipment lighting etc.).
- The external yard lighting shall be provided with timer control.
- The lighting of battery room
- The lighting of maintenance room
- The supply of sockets in RSS

- The supply of sockets in battery room
- The supply of sockets in maintenance room

Each outgoing circuit shall be protected by a miniature circuit breaker, provided with differential protection. The circuits shall always be cut off on all poles. For instance, in the case of three-phase distribution, the three conductors shall be cut-off by a four poles circuit breaker.

In the case of 2-wire supply, this shall be cut-off by a two-pole switch and shall again take place on all poles. Supply of Power socket circuits shall be made through 5 conductor cables (3 phases, neutral and ground)

c) Standby Lighting

This lighting shall automatically come into service as soon as a voltage deficiency is detected on either of the two auxiliary cabinets and shall not go through any intervening switch. The power source for this LED lighting shall come from online inverter set with automatic changeover starting ON in case of failure of AC supply.

As soon as the normal half station 415/240 V AC auxiliary sources fail and in order to prevent untimely operation when the cut-off period is too short, automated closure of the contactor shall be provided so as to energize the standby lighting system which shall take over until normal power supply is restored.

This installation shall ensure minimum lighting in the AMS building guaranteeing personnel safety and permitting, at the points where necessary, all isolation or resupply operations following total cut-off of the medium voltage sources. The standby lighting fixtures shall also be controllable.

Ventilation:

The Control Room should be Air-Conditioned with Industrial Category Heavy Duty Split AC. The High Voltage rooms shall be suitably ventilated by air circulation as follows:

- Air inlet louver at the 33 kV switchgear base,
- Air inlet at the base of each transformer cell
- Air exit at the top of each transformer cell

1st Case: Ambient air is less than 35°C, the equipment does not need any forced ventilation.

The transformer room is at least equal or higher than the 33 kV switchgear room temperature due to the fact that there is no energy spent into the switchgear. When the transformer room temperature is higher than the switchgear room temperature, a natural air convection is made through both air inlets and air exit.

2nd Case: Ambient air is more than 35°C, the equipment needs forced ventilation: in that case, the transformer air fans reinforce the natural air cooling. The fans shall be mounted on each transformer room to extract air from the room. A trap shall close automatically the aperture in case of fire detection. On the other hand, a louver shall close automatically the air inlet in case of fire detection.

d) Technical Conditions:-

The technical conditions for carrying out the works and providing the supplies are as follow:

Lighting Equipment

This shall be of LED type. LED Lights shall be type tested as per IS 10032 (5). Average lighting intensity will be 300 lux in the control rooms, and in technical rooms

- > 100 lux in the low voltage auxiliary transformer rooms > 80 lux in all other levels and in the stairway.

The LED tubes shall be mounted beneath cover glasses (as shall also be the case for the standby lighting). In the battery rooms, they shall also be mounted with glands to keep out acid vapours and hydrogen.

The sealed LED light fittings shall be capable of withstanding impacts and shall be explosion-proof (as for those in the transformer cubicles). The light fittings proposed by the PST contractor are subject to approval by the Employer.

f) Power Sockets

They shall be of sealed, wall mounted type, with four poles plus central ground, rated for 16 A and 500 V AC and with a cover flap fitted with a plug holding pin. The external sockets shall be mounted on mast, at the level of each circuit breaker.

8.5.12 Fire Protection

Auxiliary supply of each fire detection system shall be 110 V DC. In case of fire in any transformer, the fire detection system shall instantaneously come into action isolating the transformer by tripping the upstream and the downstream transformer circuit-breakers and put the fire extinction system into action. Coming into action, it shall also stop the fan working and close all apertures (air inlet and air exit) to avoid or minimize any fire propagation.

The thermo element detectors shall be mounted at the cover level of the transformer. The detectors shall detect at any moment an abnormal temperature rise generated by a fire on the tank, the terminals or even on the transformer bed.

The detectors shall be designed and equalized such that they do not operate at slow temperature rise, which may occur due to a variation of ventilation, variation load, solar

beam, etc. The design of the detectors shall ensure complete security, such that it will not operate due to any reason except for fire, and complete dependability in case of fire. If more than one detector is necessary, they shall be series mounted by a fire-resistant electric cable, which is connected to a detection unit. The detectors shall be of simple, sturdy inspect vibration proof, moisture acid resistant construction.

Provision shall be made for a guard current flowing through the detectors. Interruption of the guard current due to break of the elements series connecting cable or loose terminal shall activate an audible and visible alarm signal at the detection unit of the equipment indicating interruption of guard current. This signal must not activate the extinction system and the signal can be used for blocking of the extinction system on request. The fire detection system shall be completed inside the control room building as per specification attached at Annexure-A6.

Fire Fighting Equipment

The PST contractor shall supply minimum 4 Nos of 4.5 kg CO2 portable fire extinguishers distributed throughout the yard and equipment room each.

8.5.13 Cable Paths

General

The PST contractor shall provide all cable paths in the HV yard, in the TSS area and inside the AMS & Control Room Building.

The safe clearance as per the prescribed standard shall kept between power and control cables along the cable path.

In Open Yard

The cable path in the open yard shall be in the form of suitable RCC cable trenches with necessary ladder type (for HV cable) & perforated cable tray (for LT & Control cable) of GI steel dully supported on GI steel support and with appropriate factory made Pre-casted RCC covers having provision for lifting, peripheral edge protection angles / MS sheet or in the form of Heavy Duty PVC pipes of suitable diameter, subject to Employer's approval. All the Pre-casted RCC covers shall be sound and free from cracks and other defects which interferes with the proper placing of the unit or impair the strength or

performance of the units and shall be suitable for load of 100 kg. The galvanization on cable tray / ladder and support bracket shall be minimum 1000 gm/sqm.

Inside Rooms

The cable path inside rooms shall be in the form of suitable RCC cable trenches with necessary ladder type (for HV cable) & perforated cable tray (for LT & control cable) of GI steel dully supports on GI steel support and covered by steel/GI checker plates of good and aesthetic quality.

Separation of different voltage families

As the cable routes are dealing with different voltage family, they have to be physically separated.

Cable Route Plan

The PST contractor shall submit cable route plan, cable trench cover drawings, to the Employer, for approval, well in time.

8.5.14 Boundary Walls

Along the periphery of the Substation site, a 3.0-meter height from FGL boundary wall matching with the finish of building, consisting of RCC retaining wall, columns, beams and BSBRP logo panels as per BSTP design & specification, shall be constructed by the RSS PST contractor . Appropriate MS gates of size 7 meter in width with small gate of approved design shall also be provided to permit movement of personnel/goods.

Suitable size of medium class GI pipe, Y-post bracket with GI concertina wire of 0.5 meter height shall be provided on the top of the boundary wall panel as per drawing.

8.5.15 Guard Room

The RSS-cum-AMS-cum-TSS shall be provided with a Guard Room, near the main gate. Suitable communication link between the Guard and the Substation operator located in the Control Room, shall be provided. The Guard shall be able to open the gate only when he is authorized by the Substation Operator to do so and a suitable interlocking arrangement to achieve this Security arrangement, shall be provided.

The specification shall be similar or matching to main building. The guard room shall be equipped with Air-Cooler and toilet. CCTV shall also be provided to look after the RSS premises whose feed shall be given in control room or guard room as per employer's requirement. LED screen for the same shall be provided and included in the scope of work.

8.5.16 Signages

The entire RSS-cum-AMS-cum-TSS premises shall be provided with suitable Signages as per RDSO specification. Depending upon the layout and construction finally adopted, the various installations (e.g. TSS, AMS, HV Bay, Transformers, Control Room etc.) shall be provided with Sign boards, both in Hindi and English. These Sign boards are in addition to Equipment labeling, which shall be provided as per approved drawing. The PST contractor shall submit drawings for the proposed Signages, for Employer's approval and the Signages shall be provided in accordance with approved drawings.

The PST contractor shall provide suitable signages including the the sign board at main gate and on the suitable location of building (in Hindi and English) and other relevant indicators as per the drawing and material to be approved by Engineer

8.5.17 Storage Space

Covered storage space for spares, oil drums, cable drums etc. of approx. 150 sq. m. Area should be provided in the RSS where land is available. The land will be marked in the RSS layout and decided at execution stage. The storage space should be made of covered shed of rain proof material, with brick walls, suitable rolling shutters for bigger size of spares and heavy-duty doors & windows to be provided.

Fans, exhaust fans, lighting provisions should be provided. The floor to be of cemented type. All materials should be of durable quality and of reputed makes as used in other civil works of RSS.

8.5.18 Land Scaping

The RSS cum TSS cum AMS shall be provided with landscaping and plantation, pebbles block with grass, on vacant areas left after the construction of substation as per IGBC requirement to get platinum rating.

The plantation shall be provided on both sides of approach road to the control room from the Main Gate, along the boundary walls inside the RSS boundary, on the both sides of entry doors of the control room. Good quality plants, green plants, shrubs should be provided and suitably placed. The care and maintenance of land scaping and plantations provided shall be carried out upto the end of the DLP period. The types of plants not limited to be provided are as follows:

- Plumeria (Champa)
- Ficus Penda
- Ficus Benjamina

8.5.19 Civil Specifications:

The further details of the civil specifications are attached as Annexure-A1

8.5.20 If Site not available at the time of bidding or changed after award of work:

If Site not available at the time of bidding or changed after award of work, No cost implication on account of increased depth of foundations shall be allowed upto 3mts. Any changes in the foundation work, more than 3 meters from Top of equipment foundation/plinth beam of building to raft level shall be paid extra only

difference in height) based on prevailing CPWD/DSR/state civic agency's rates with cost Index

8.5.21 Chain link fencing:

Fencing shall be done as per latest RDSO/CPWD specifications and as per site conditions. A detailed drawing along with layout shall be prepared and submit for approval of Engineer-in-charge.

9. AMC: Refer DLP and Spare Policy attached with Preamble of BOQ

10. SCADA Equipment Status

Status of local Main/Standby Servers, Gateways and Network switches to be made available at OCC.

Reporting

Complete detail of disturbance recorder (DR) should be available at OCC. In case of tripping of 25 kV feeders, details regarding fault distance, fault current and fault voltage should be available at OCC.

ANNEXURE-A1 CIVIL WORK SPECIFICATION

1. GENERAL INSTRUCTIONS

These specifications contained herein shall be read in conjunction with other tender documents.

The work shall be carried out in accordance with the “Good for Construction” drawing and designs as would be issued to the PST contractor by the Engineer duly signed and stamped by him. The PST contractor shall not take cognizance of any drawings, designs, specifications etc. not bearing Engineer's signature and stamp. Similarly, the PST contractor shall not take cognizance of instructions given any other Authority except the instructions given by the Engineer in writing.

Reference to the Standard Code of Practice:

PST contractor shall make available all relevant codes of practice at Site as applicable along with the following's major codes with up-to-date revision/correction slips and other relevant specifications described in these specifications.

- (i) ASCE (American Society of Civil Engineers)
- (ii) ASME (American Society of Mechanical Engineers)
- (iii) ASTM (American Society of Testing Materials)
- (iv) BS (British Standard)
- (v) CPWD (Central Public Works Department)
- (vi) IS (Indian Standards)
- (vii) IRS (Indian Railway Standards).
- (viii) MORTH

Detail site survey shall be carried out and locate the existing nearby structure of RSS, which could be affected during constructing activities such as excavation, concreting, etc. and necessary arrangements or precaution shall be taken by the PST contractor at his own cost in order to protect the same. Method statements shall submit separately for approval of Engineer-in-charge.

Layout drawing shall be prepared indicating basic facilities such as Site office, Testing Laboratory, canteen (optional), toilet, wheel-washing facility etc. and submit for approval of Engineer-in-charge.

1. Earthwork

No claim whatsoever on account of any discrepancy between the sub-surface conditions that may be actually encountered at the time of execution of the work and those given in these Tender Documents shall be admissible to the PST contractor under any circumstances whatsoever.

Excavation shall be carried out in any material met on the site to the lines, levels and contours shown on the detailed drawings and the PST contractor shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed.

Excavated material shall not be deposited within 1.5m from the top edge of the excavation.

Excavation for all works and of materials required for filling shall be to the exact width, length and depth shown on the drawings or as directed by the Engineer. Where the nature of soil or the depth of the trench and season of the year, do not permit vertical sides, the PST contractor at his own expense shall put up the necessary shoring, strutting and planking with due regard to the safety of personnel and works and to the satisfaction of the Engineer. The construction barricading will have a width of 7.0m (outside to outside of barricading). This can be increased at specific locations with approval of Engineer. The PST contractor shall submit method statements for approval of Engineer demonstrating how this will be achieved at site. If required, driving of rolled section / sheet pile of suitable size shall be done into the soil to retain earth as directed by Engineer.

Foundation pits/trenches shall not be excavated to the full depth unless construction is imminent. The last fifteen (15) cm depth of the excavation shall not be done until concreting work is imminent. The full depth may at the discretion of the Engineer-in-Charge be excavated and the bed covered with a fifty (50) mm (minimum) thick (or as indicated on drawing) layer of lean concrete 1:4:8 mix (1cement: 4 coarse sands: 8 crushed stone aggregate) if shown in the drawing, or after watering if required, and consolidating the bed.

If the bottom of any excavation has been left exposed by the PST contractor and in the opinion of the Engineer-in-Charge, that has become badly affected by the atmosphere or by water, then the PST contractor shall remove such portions of the deteriorated material as the Engineer-in-Charge may direct and shall make good with lean concrete 1:4:8 mix (1 Cement: 4 Coarse Sand: 8 Crushed Stone Aggregate). All expenses for such additional concrete and excavation shall be borne by the PST contractor .

Where excavation is made in excess of the depth required, the PST contractor shall, at his own expense, fill upto required level with lean concrete 1:4:8 mix (1 Cement: 4 Coarse Sand : 8 Crushed Stone aggregates) or as decided by Engineer-in-Charge. If excavation is carried out to greater width and length, such extra width and length shall be filled in by Yamuna sand.

The PST contractor shall provide suitable drainage arrangement to prevent surface water from any source entering the foundation pits at his own cost.

The PST contractor shall make all arrangements for dewatering during excavation and subsequent works, the accumulated water from any source (including subsoil water) in the excavated pits/trenches and keeping the excavated pits/trenches dry for subsequent works.

The PST contractor shall make necessary arrangements for lighting, fencing and other suitable measures for protection against risk of accidents due to open excavation.

The sides of the excavation may be cut sloping or shored and strutted to hold the face of earth as per site requirements and as directed by the Engineer-in- Charge. Where the excavation is to be carried out below the foundation level of an adjacent structure, the precaution to be taken such as under pinning, shoring and strutting etc. shall be determined by the Engineer- in-Charge. No excavation shall be done unless such precautionary measures are carried out as per directions of the Engineer-in-Charge. The payment for such precautionary measures shall be borne by PST contractor .

Loose or soft bed ground encountered in excavation at the required depth shall on the Engineers-in-Charge's instructions be excavated to a firm bed and difference made up to the required level with lean concrete 1:4:8 mix (1 Cement: 4 Coarse Sand: 8 Crushed Stone Aggregates)

Any obstacle encountered during excavation shall be reported immediately to the Engineer-in-Charge and shall be dealt with as instructed by him.

The PST contractor shall not undertake any concreting in foundation until the excavation pit/trench is approved by the Engineer-in-Charge.

The specification for earth work shall also apply to excavation in rock in general.

Near habitations and traffic prone areas, trenches and foundation pits or any other excavation work shall be fenced, provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents. The PST contractor shall take all adequate protective measures to see that excavation operations do not affect or damage adjoining structures.

Excavation material required for filling shall be stacked or dumped where indicated by the Engineer. Excavated material not required for filling and any surplus material shall be removed or spread on the site as directed by the Engineer. Dumping of this surplus material shall be in an environmental friendly manner using trampoline cover, dumper, placer etc and according to the levels/grades as indicated by the Engineer. The cost of such removal and spreading shall be borne by the PST contractor and deemed to be included in the Contract Rates. Necessary approval from the local authorities for carting and dumping surplus material is to be obtained by the PST contractor .

2. Back Filling around Foundations and In Plinth

Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings including any trimming of the surfaces, as may be necessary. Where sufficient suitable material is not available from the excavation, the Engineer-in-Charge may direct to import suitable earth from other sources. The filling shall be done in layers of thickness not exceeding 15 cm with watering, rolling and ramming by manual methods/ mechanical compactors to grade and level as shown on drawings to obtain 95% laboratory maximum dry density.

In case sand is used for backfilling in foundation and plinth, it shall be got approved by the Engineer. In the foundation, the backfilling shall be done in layers not more than 200mm thick and shall be thoroughly watered and consolidated by approved method. The rate for backfilling using sand in foundation/Trenches shall be borne by PST contractor .

Backfilling material shall be as approved by the Engineer-in-Charge.

The material shall be free from rubbish, roots, hard lumps and any other foreign organic material. The compaction of filling shall be carried out as specified in drawings or as directed by engineer in charge.

For open foundation resting on rock, if the sound rock is located at very shallow depth, the PST contractor is required to cut the rock (of all type or strength) to a depth so that open foundation with a minimum earth cushion of 500mm may be accommodated.

In order to protect the ground floor of control room building, brick wall of 230mm thickness shall be provided below the Plinth beam along the periphery of the control room building. Height of such brick wall shall be measured from Plinth beam (bottom) at a depth of 2.0m or foundation level (bottom of PCC) whichever is smaller. In case building foundation is more than 2.0 m then a tie beam shall be provided at the depth of 2.0m and brick work shall be done from the tie beam.

3. Concrete: Plain & Reinforced

These specifications shall be read in conjunction with the IS: 456-2000 and CPWD specifications 2009 with up-to-date correction slips. Minimum grade of Ready-Mix concrete shall be of M-30 and P.C.C of M-15. Concrete cubes shall be cast, tested and evaluated as specified in IS: 516 and PST contractor shall provide the facility at site for the same at his own cost.

4. Materials

Before bringing to the site, all materials for concrete shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought on to the works shall conform in every respect to their approved samples.

Fresh samples shall be deposited with Engineer whenever type or source of any material changes. The PST contractor shall check fresh consignment of materials it is bringing on to the works to ensure that they conform to the specifications and/or approved samples.

The Engineer shall have the option to have any of the materials tested to find whether they are in accordance with specifications at the PST contractor's expense. All bills vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

Any materials, which have not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the PST contractor at his own cost within the time stipulated by the Engineer. The Engineer shall have the powers to cause the PST contractor to purchase and use materials from any particular source, as may in his opinion be necessary for the proper execution of work.

PST contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform color and texture.

5. Cement

Cement used, shall be of approved manufacturers, brand as listed in "Annexure- A" and shall be of the following types:

- a) 43 grade Ordinary Portland Cement conforming to IS:8112- For Plaster/Mortar
- b) 53 grade Ordinary Portland Cement conforming to IS:12269- For Concreting work

For piling and foundation work, slab at grade, underground structures and all structures in contact with earth, type of cement shall be as mentioned in **clause 5** on pile foundations.

Whenever possible all cements of each type shall be obtained from one constant source throughout the contract, cement of different types shall not be mixed together. Different brands

of cement or the same brand of cement from different sources shall not be used without prior approval of the Engineer.

PST contractor may obtain cement in bulk and store it in suitable silos of adequate capacity each type of cement shall be stored in a separate silo and it shall be ensured that cements of different quality are not mixed up.

All cement shall be fresh when delivered and at ambient atmospheric temperature.

In fair faced elements, the cement used in the concrete for any complete element shall be from a single consignment. All cement for exposed concrete shall be from the same approved source and uniform in colour.

Packaged cement shall be delivered to the site in original sealed bags, which shall be labeled with the weight, name of manufacturer, brand and type. Cement received in torn bags shall not be used. The PST contractor shall provide complete facilities at his own cost at site for carrying out the following tests:

- a) Physical Test for Hydraulic cement as per IS:4031
- b) Consistency of Cement Paste by vicat's apparatus as per IS:4031 and IS:5513
- c) Compressive strength on cement as per IS:4031, IS:650 and IS:10080
- d) Soundness Test of Cement by Le Chaterlier Apparatus as per IS:5514

Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total Sulphur content calculated as Sulphuric Anhydride (SO₃), shall in no case exceed 2.5 percent and 3.0 percent when tri-Calcium Aluminate per cent by mass is upto 5 or greater than 5 respectively.

6. Aggregate

Aggregates from natural sources shall be in accordance with IS:383 The PST contractor shall submit to the Engineer certificates of grading and compliance for all consignments of aggregate. In addition at site from time to time, the PST contractor shall allow for carrying out such tests and for supplying test records to the Engineer. The aggregates shall be procured from approved sources only as directed by the Engineer from time to time.

For fair faced concrete, the PST contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

7. Fine Aggregate

The PST contractor shall provide complete facilities at site for determining grading of aggregates by sieves as per IS:383, IS:460, IS:1607 and IS:2386. Grading of aggregate shall be within the grading zones I, II, III.

Fine aggregates shall be river sand, pit sand, stone dust or other approved sand. It shall be free from clay, loam, earth or vegetable matter, salt or other harmful chemical impurities. It shall be clean, sharp, strong angular and composed of hard siliceous material.

The PST contractor shall provide complete facilities at site for carrying out following tests:

- a) Proportion of clay, silt and fine dust by sedimentation method as per IS:2386 part II.

- b) Moisture content in fine aggregates as per IS:2386 part-III.
- c) Bulk density / Bulkage.

8. Coarse Aggregate

The coarse aggregate shall be crushed stone. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any other deleterious material.

Coarse aggregate shall conform to IS:383 and testy for conformity shall be carried out as per IS:2386, part I and IV

Maximum size of coarse aggregate shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the concrete of formwork. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20mm.

9. Brick

Brick work at site should be done as per IS 2212. The PST contractor shall provide complete facilities at site for carrying out following tests as per IS 3495:1992

- a) Dimensional tolerance
- b) Water absorption
- c) Efflorescence
- d) Compressive
- e) strength

10. Water

Water from approved source

Potable water only shall be used for the works. PST contractor shall have his own source of water duly approved by Engineer. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

However, the chloride content in water shall not exceed 500mg/litre..content in water shall not exceed 500mg/litre.

Storage:

The PST contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to see that water is not contaminated in any way.

Testing:

Before starting any concreting work and wherever the source of water changes, the water shall be sampled and tested accordance to IS:3025-2009 for its physical, chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water

shall be used until tested and found satisfactory. Cost of all such Tests shall be borne by the PST contractor .

Transporting, Placing, Compacting And Curing:

Transporting, placing, compacting and curing of concrete shall be in accordance with IS: 456 and other relevant codes.

Transporting:

The mix after discharging from the mixer shall be transported by transit mixers, buckets, pumps etc. or as approved by the engineer without causing segregation and loss of cement slurry and without altering its desired properties with regard to water cement ratio, slump, air content, cohesion and homogeneity. It should be ensured that the concrete is moved to its final destination before it attains an initial set.

The transportation is to be done by agitating transit mixers, pumps or other approved methods.

Placing:

The method of placing shall be such as to prevent segregation by providing windows in the formwork for pouring concrete or by Tremie pipe (For Pile). The thickness of horizontal layers shall not exceed 300mm. High velocity discharge of concrete causing segregation of mix shall be avoided. The concrete shall be placed in the forms gently and not dropped from a height exceeding 1.5m except in columns where the maximum allowed will be 2.0m. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other so closely that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken initial set.

For columns/walls shear key shall be provided on the head portion of the columns/walls of 1st stage, and before starting the 2nd stage of concrete, shear key area shall be clean properly, so that concrete gets a proper bonding.

Concreting of any portion or section of the work shall be carried out in one continuous operation and no interruption of concreting work will be allowed without approval of the Engineer.

Compaction:

Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete.

Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc, and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

- (i) Air bubbles cease to come to surface.
- (ii) Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.
- (iii) The tone of the vibrated concrete becomes uniform.
- (iv) Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.

- (v) After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate, into the layer of fresh concrete below if any for a depth of about 150mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.
- (vi) To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.
- (vii) A sufficient number of spare vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.
- (viii) Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new formwork and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.
- (ix) Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.
- (x) Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.
- (xi) Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground and with water draining there from during placing and for a period of seven days or as otherwise instructed thereafter. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, abrasion, vibrations, deleterious ground water, mixing with earth or other materials, and other influences that may impair the strength and durability of the concrete.

Curing:

- (a) Curing of concrete shall be complete and continuous using potable water free from chlorides and sulphates water that is free of harmful amounts of deleterious materials that may attach, stain or discolor the concrete as per IS 456. Minimum wet curing will be for seven days by ponding water followed by moist curing by spraying water which shall be maintained up to a total period for at least 21 days from the date of casting.
- (b) Immediately after compaction and completion of any surface finishes the concrete shall be protected from the evaporation of moisture by means of polythene sheathing, wet Hessian or other material kept soaked by spraying. As soon as the concrete has attained a degree of hardening sufficient to withstand surface damage moist curing shall be implemented and maintained for a period of at least 15 days after casting.
- (c) Method of curing and their duration shall be such that the concrete will have satisfactory durability and strength and members will suffer a minimum distortion, be free from excessive efflorescence and will not cause undue cracking in the works by shrinkage.
- (d) Steam curing with approved methodology can be adopted if required, for precast units. No extra payment will be made for adopting steam curing.
- (e) Curing compounds of approved manufacturers or brands as listed in "Annexure- A" may be permitted with Engineer's Approval. However, it is required to be proved that after using curing compound, the concrete shall not have less strength than concrete cured by water curing. It shall not have any discoloration on the structural concrete.

Admixtures

Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, amount and method of use of any admixtures proposed by the PST contractor shall be submitted to the Engineer for approval. The minimum cement content specified shall not be reduced on account of the use of the Admixtures.

The PST contractor shall further provide the following information concerning each admixture to the Engineer:-

- (a) Normal dosage and detrimental effects if any of under dosage and over dosage.
- (b) The chemical names of the main ingredients in the admixtures.
- (c) The chloride content, if any, expressed as a percentage by weight of admixture.
- (d) Whether or not the admixture leads to the entrainment of air when used in the manufacturer's recommended dosage.
- (e) Where two or more admixtures are proposed to be used in any one mix, the manufacturer's written confirmation of their compatibility.

In reinforced concrete, the chloride content of any admixture used shall not exceed 2 percent by weight of the admixture as determined in accordance with IS:6925 and the total chloride and sulphate contents in concrete mix shall not exceed 0.15 and 4.0 percent respectively by weight of cement.

The admixtures when used shall conform to IS: 9103. The suitability of all admixtures shall be verified by trial mixes.

The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.

Retarding admixtures when used shall be based on ligno-sulphonates with due consideration to clause 5.2 and 5.3 of IS: 7861.

Reinforcement

These specifications shall be read in conjunction with the CPWD specifications 2009 with up-to-date correction slips. Only TMT bar of approved manufacturers or brands as listed in "Annexure- A" shall be used of Grade not less than Fe-500D at any case. However, if necessary, introduction of new grade can be directed by Engineer-in-charge as per the latest relevant Indian standard and PST contractor is bound to implement the same without any financial benefits. The reinforcement steel shall be from Primary products and no re-rolled steel shall be supplied.

Any steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS:2502 Bending and Fixing of Bars for Concrete Reinforcement.

Inspection & Testing as per IS 1786:2008:

Every bar shall be inspected before assembling on the works and any defective, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

No work shall be commenced without the Engineer's approval of the bar bending schedule.

Manufacturer's Certificate shall be supplied for each lot of supply.

Specimens sufficient for three Tensile Tests for each different size of bar for each consignment delivered, or for 10 tonnes of supply of that size, whichever is less shall be sampled and tested by the PST contractor. Batches shall be rejected if the average results of each batch are not in accordance with the specifications.

Bar bending and Bar Bending Schedule:

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material.

Prior to starting bar bending work, the PST contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. Any discrepancies and inaccuracies found by the PST contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall be accepted.

Lapping & Welding/Mechanical Splicing:

- (a) As far as possible bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the PST contractor of bars of maximum length. In case the PST contractor wishes to use shorter bars, laps/couplers (approved make with permission of Employer's Engineer) shall be provided in the manner and at the locations approved by the Engineer.
- (b) Bars having butt or lap welds shall be provided as specified in the drawings or as instructed by the Engineer.

Spacing, Supporting and Cleaning:

- a. All reinforcement shall be placed and maintained in the positions shown on the drawings to be prepared by PST contractor.
- b. The PST contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape and size, M.S. Chairs and spacer bars shall be used to ensure accurate positioning of reinforcement. Cover blocks shall be cast well in advance and shall consist of approved proprietary pre-packaged free flowing mortars (Conbextra HF of Fosroc or equivalent). They shall be circular in shape for side cover and square for bottom cover. The cost of cover block shall be deemed to have been included in the rates.
- c. Anti corrosion coating (at-least 03 coating) shall be applied to all reinforcements before using them in any structure. Prior approval of Engineer's may be required in order to select the make of the materials.
- d. Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete.
- e. G.I. wire shall be used for binding reinforcement

Structural Steel:

All structural steel shall be hot deep galvanized by zinc coating having thickness 1000gm/sqm and of tested quality and shall conform to following standards:

IS: 226 Structural steel (Standard Quality)

IS: 2062 Grade-B Structural steel (Fusion Welding quality)

IS: 961 High Tensile Structural Steel (Ordinary)

IS: 1161 Steel Tubes for Structural purposes

IS: 8500 – Grade Fe 540HT

The PST contractor shall supply to the Engineer copies of the manufacturer certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specification. If required by the Engineer, the PST contractor shall arrange for testing of the steel samples as per IS:1608 – 1599.

Bolts and Nuts

For splicing of any structural member wherever required HSFG bolts and nuts of property class-8.8 conforming to IS-3757 and IS:6623 (1985) respectively shall be used. Unless specified otherwise, the bolts shall be hexagonal.

All anchor bolts shall be of property class of 8.8 and nuts shall conform to IS:1363 (1992). IS:1364 (1992) and IS:1367 as applicable and unless specified otherwise, shall be hexagonal. All nuts shall conform to property class compatible with the property class of the bolt used.

For HSFG bolts, washer shall be conforming to IS:6649 (1985)

Plain washers shall be conforming to IS:5369 (1975) unless otherwise specified. One washer shall be supplied with each bolt and in case of special types of bolts, more than one washer as needed for the purpose shall be supplied. An additional double coil helical spring washer, conforming to IS:6755 (1980) shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Tapered washers, conforming to IS:5372 (1975) and IS: 5374 (1975) shall be used for channels and beams respectively wherever required.

Templates

Templates used throughout the work shall be of steel in cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

Clearance

The clearance between fraying surface of bolted connections shall not be greater than 1mm at each end. If separation is between 1 to 3mm the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

Drilling

Holes for bolts shall be drilled to conform to Clause 10 of IS:7215-1974. Punching of holes shall not be permitted. All holes except as staged hereunder, shall be drilled to the required size, 3mm less in diameter and reamed thereafter to the required size. All matching holes for bolts shall register with each other so that a gauge of 0.8mm less in diameter than the hole can pass freely through the members assembled for bolting, in the direction at right angle to such members.

- a) All drilling shall be free burrs.
- b) No holes shall be made by gas cutting process.

11. Pile Foundation

Setting Out:

The PST contractor shall establish and maintain permanent datum level points, base lines

and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker the position of each pile. The setting out of each pile shall be agreed with the Engineer at least 8 working hours prior to commencing work on a pile and adequate notice for checking shall be given by the PST contractor .

Notwithstanding such checking and agreement, the PST contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

Cement:

- a. The cement to be used for piling and all foundation work shall be conforming to following Indian Standard Specifications.
- b. IS: 455 Specification for Portland slag cement

Cement shall be free from lumps and caking.

Concrete Mix Design

The concrete shall be M30 size of coarse aggregate shall not exceed 20mm. For cast-in-situ piles concrete with a slump of 150 to 175mm (consistent with the method of concreting) will be required. Minimum cement contents for design mix shall not be less than 400kg/m³ of concrete in piling. For piling Qty. of cement shall be as per the design mix or the minimum cement content whichever is greater shall be used.

The PST contractor shall submit mix design calculations and get the approval from Engineer well before the starting of installation of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

Concrete cube tests

Concrete cubes shall be cast, tested and evaluated as specified in IS:516 and PST contractor shall provided the facility for the same at site.

7.5. Reinforcement:

- a. The reinforcement shall conform to the requirements specified in clause 3. extending for the full length of the pile and shall project 60 times bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover.
- b. Joints in main longitudinal bars will be permitted only where in the opinion of the Engineer, each bar cannot be supplied in one complete length where permitted joints shall be provided at agreed centers, designed to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups and staggered in position from those of adjacent longitudinal bars, all to be approval of the Engineer.
- c. All main longitudinal bars shall be tack weld at lapping if any and to the pile cap reinforcement. The last one circle of helical stirrups at each end shall be welded to main longitudinal bars.

Cast In-Situ Bored Piles:

General:

- 1) Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.
- 2) These shall be formed by boring to the founding strata specified on the drawing or as

directed at site. The sides of the boring shall be prevented from collapsing by one of the following:

- (i) Permanent mild steel liner (cased pile)
 - (ii) Removable mild steel casing (uncased pile)
- 3) Piles shall be constructed in a sequence approved by the Engineer. During boring, the PST contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory or carry out soil tests as directed.
 - 4) The method adopted shall be chosen giving due consideration to the subsoil data ground water conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.
 - 5) The bottom of the steel lining shall be sufficiently in advance of the boring tool to prevent settlement of outside soil and formation of cavities.
 - 6) Removable mild steel castings shall be used only with extreme caution individual castings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.

Boring:

- a. Boring shall be done using hydraulic drilling rigs with oscillator arrangement suiting to different kinds of strata encountered.
- b. Use of liner for type 4 to 6 meters from ground level or more depth, to protect loose soil falling in bore hole as directed by engineer, is essential.
- c. Bentonite slurry shall satisfy the following properties as all times:
 - Mud density shall not exceed 1.05 g/cc
 - Marsh Cone viscosity 30.40 seconds
 - The sand content of Size < 0.075mm shall not be more than 1 percent.
 - Liquid limit of bentonites shall not be less than 400 percent
 - Bentonite shall be saturated for 24 hours and then used
- d. When using bentonite mud, flushing shall be done after lowering of inserting reinforcement cage and tremie before starting of concreting with fresh bentonite slurry.

Penalty on mishandling of bentonite

Mishandling of bentonite (like splashing of bentonite outside specified width of barricading of non-cleaning of tires of dumpers and transit mixers before leaving the piling site thereby making the road dirty etc is strictly prohibited. Noncompliance of same shall attract a penalty as follows:

- a. On first observation - Rs. One lac
- b. On second observation - Rs. Two lacs.
- c. On third and each subsequent observation - Rs. Three lacs.

Alignment of Piles

Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles and 4% for rake piles. Piles should not deviate in location by more than 75mm when used in groups. For single or 2 piles used under columns, deviation shall not be more than 50mm.

The PST contractor shall maintain a record of actual pile locations in the form of drawing and submit the information to the Engineer at suitable intervals.

Defective Piles

The Engineer reserves the right to reject any pile, which in his opinion has not been constructed in accordance with the specifications.

The PST contractor will not be paid for rejected piles. The increase in cost of the pile caps, tie beams and other measures adopted for strengthening because of rejection of defective piles shall be borne by the PST contractor.

As- Built Drawings

On completion of the work, the PST contractor will submit a plan showing the exact location and length of each pile as constructed at site, as well as dates of concreting, cube test results etc. The original tracing of this drawing shall be submitted to the Engineer.

12. Storage of Materials

General

All materials shall be so stored as to prevent deterioration, and to ensure the preservation of their quality and fitness for the work if required by the Engineer. The materials shall be stores under cover and suitably painted for the protection against weather any material, which has deteriorated or has been damaged shall be removed from site and replaced by new members, as directed by the Engineer at no extra cost and time.

The steel to be used in fabrication shall be a stored in separate stack clear of the ground section wise and lengthwise.

The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled in such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids to avoid unacceptable deflection.

Covered Steel

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground in a properly covered building by the PST contractor.

Paint

- a. All paint delivered to the fabrication shop/Site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
- b. Paint shall be stirred frequently to keep the pigment in suspension.
- c. All paint shall have a low VOC content.

Storage of Paints

All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.

All paint container shall be clearly labeled to show paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage shall not be used. The Engineer shall not use paints for which the shelf life specified by the supplier has expired without inspection and approval by the Engineer.

Scaffolding

All scaffolding as required shall be provided till the completion of work. PST contractor shall have to be checked the scaffolding materials into a regular interval so that defective materials shall be ruled out from the site.

Tolerance for Finished Work

The finished work shall conform to the following tolerance.

- a. All the hairline joints shall be in perfect lines and levels.
- b. Plumb
 - (i) In any 3m + 5mm
 - (ii) Maximum per floor +10mm
 - (iii) Maximum for total height + 15mm
- c. Horizontal
 - (i) In any 3m + 5mm
 - (ii) Maximum for total length + 10mm

Formwork For Exposed Concrete Surfaces:

The facing formwork, unless indicated otherwise on drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure:

- i. Plain slab soffit and sides of beams, girders, joists and ribs and side of walls, fins, parapets, parrises, sun-breakers, etc shall be made with:
 - a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane

- b. Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length,
 - c. Plywood not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) or 3mm thick plywood with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework. At joints 6mm/10mm sponge to be provided.
- ii. Bottoms of beams, girders and ribs, sides of columns shall be made with:
 - a. Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane
 - b. Timber planks of 35mm actual thickness and of specified surface finish, width and reasonable length,
 - c. Plywood plates not less than 12mm thick, of specified sizes stiffened with a suitable timber framework.
 - d. For sub stations suitable steel formwork is to be used unless as specified by Engineer.

For Sloped Surfaces

1. Forms for sloped surfaces shall be built so that the formwork can be placed board-by-board immediately ahead of concrete placement so as to enable ready access for placement, vibration inspection and finishing of the concrete.
2. The formwork shall also be built so that the boards can be removed one by one from the bottom up as soon as the concrete has attained sufficient stiffness to prevent sagging. Surfaces of construction joints and finished surfaces with slopes steeper than 2 horizontal: 1 vertical shall be formed as required herein.

Formwork For Curved Surfaces:

1. The PST contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form lumber shall be built up of laminated splices cut to make tight, smooth form surfaces.
2. After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature.

Formwork For Waffle Slab:

Shuttering for Waffle Slab/ Coffered Slab shall be with Fibre Glass moulds of approved design. They can also be of Precast concrete unit as per design to form as part of structural concrete. The moulds shall be of uniform shape and dimension to give the desired shape of Coffered slab.

Age of Concrete At Removal Of Formwork:

Age of Concrete at Removal of Formworks shall be in accordance with CPWD Specifications 2009 and IS: 456, with upto date correction slips. The Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

Reuse of Forms:

The PST contractor shall not be permitted reuse of timber facing formwork brought new on the works more than 5 times for exposed concrete formwork and 8 times for ordinary formwork.

5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may in his absolute discretion order rejection of any forms he considers unfit for use for a particular item irrespective of no of items the shuttering has been used and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be

allowed. If any other type of special or proprietary form work is used, the no. of times they can be used will be determined by the Engineer.

Annexure- A1B**EMPLOYER'S REQUIREMENTS****INDICATIVE MANUFACTURERS LIST**

All materials and products shall conform to the relevant standard specification. IS codes and other relevant codes etc. and shall be of approved makes and design

The list of indicative makes for products and material is given below. Other equivalent manufacturers will only be considered with prior approval of the Employer in case of non-availability of unforeseen difficulties.

Sl. No.	Details of Materials/Products	Manufacturer's Name
1	Cement	ACC, Ultratech, Gujarat, Ambuja, Birla Grasim, JK
2	Reinforcement Bars	SAIL Plants. Rashtriya Ispat Nigam Ltd. (Vizag steel Plant, Andhra Pradesh), Tata Steel (Jharkhand), Ispat Industries(Maharashtra), JSW Steel (Karnataka) and Essar Steel (Gujarat) and any other integrated steel plant as per Ministry of Steel's definition.
3	Epoxy	FOSROC, SIKa, QUALCRETE, Araldite, BASF, Kunal Conchem, SWC, Don Chemicals, STP
4	Expansion Joints	Empanelled Suppliers as per Ministry of Road Transport & highways letter no. RW/NH-34059/1/96-S&R date 20 Feb 2001 & any amendments to the same or as approved by Employer's Engineer
5	Admixtures	FOSROC, MBT, Asian Lab, MC Baucheme, Sika, Chemicals, Pidilite, Polygon, SWC, Choksey, STP, MYK Schomburg, BASF, Don.
6	Waterproofing System	CICO, FOSROC, SIKa PLAN, MBT, BASF, SWC, Pidilite, MYK Schomburg, Kunal Conchem, Don, STP
7	Anchor Fastener	HILTI, FISHER, Cannon, Pooja Forge, AXEL Industries Panchseel, Pioneer Nuts And Bolts (Tuff Brand)
8	Structural Steel	TATA, SAIL, ESSAR, Maharashtra Pipes, Jindal Steel & Power Ltd., JSW, JSPL
9	Welding Electrodes	ESAB, Advani-Orlikon Weld Alloy, Modi Arc/Weld Excel India, GEE, Honavar, K.M. Crown Welding Consumables, Supercon Schweissttechnik, Dwekam Electrodes, L&T Eutectic, Victor
10	Horizontal Tie Bars/Shear	BB Bars System of equivalent
11	Formwork Release Agent	FOSROC, MBT, MC Baucheme, Ado Conmat, CICO, SWC, Choksey, BASF

12	Reinforcement Couplers	Dextra, Moment or equivalent
13	Waterproofing Membrane	Texas India, BASF, FOSROC, SWC, STP Ltd, CETCO Ashapure JV
14	Non shrink Grout	FOSROC Chemical (India), SIKA BASF, ELCHEM, MBT, Sika, SWC, Don Choksey
15	Poly-sulphide Sealant	CICO, Pidilite, BASF, FOSROC, SWC
16	Steel Structural Fasteners	Pooja Forge, Sundram Fasteners, Unbrako, Nelson, Panchsheel
17	Paints	Berger, Johnson, Nicholson, Nerolac, Asian, Akzo Nobel, PPG
18	Plywood	Duroply (Greenmarked BWR Grade of Sarda Plywood Industries Ltd.). Century Plywood Green Plywood, kply India Ply
19	Curing Compound	Clean tech concure, SINAK, FOSROC, TAM, STP, CHRYSO, CICO, DON
20	Float Glass/Toughened Glass/Insulating Glass/ Laminated Glass	Flat Glass India Ltd./Asahi Float/Modiguard Reliable Safety Glass Ltd./ Glaverbel/Saint Gobain/Tata Float
21	Powder Coatings	Berger/Nerocoat/Jenson & Nicholson
22	Title Joint Filter	Roff Rainbow Title Mate of Roff Construction Chemicals Pvt. Ltd./Winsil 20/Silicon Sealant of GE Bayer Silicon/Zentrival
23	Ceramic Tiles	Kajaria/Bell/Johnson/Nilco/Somany
24	Glass Mostac Tiles	Mirdul Enterprises/Italia/Bisazza

25	Modified Bituminous Membrane Roof waterproofing	Multiples standards of integrated water proofing Membrane limited SUPER Thermolay/Polyflex of STP Limited/Lotus-3 of the Structural Waterproofing Co. Limited/Heavy Duty Poyply of Ana Roofings Private Limited.
26	Epoxy Putty	"Techoxy" by Choksey Chemicals Pvt. Ltd. Toyo Ferrous Crete (P) Ltd.
27	Fire Door	Signum, Shakti Met, Goddrej, Radiant, Pacific, Global Fire Protective Agency
28	Door Fitting, S.S. door handles, heavy duty door	Dorma, Hafele, Doorset, Dline
29	Stone cladding clamps	Hilti, Fisher, Canon
30	Textured plaster	TEXFIN products (M/s. NIKO)
31	Wall Putty	M/s. JK White Cement Works/Ms. Modi Industries Ltd. (Paint section)/Toyo Ferrous Crete (P) Ltd.
32	Epoxy paint, Epoxy clear primer, Epoxy polyurethane floor coating epoxy Screed, Epoxy seat	M/s H C Associates, Asian
33	Mineral Fibre False Ceiling	Armstrong, India Gypsum
34	Metallic false ceiling	Armstrong, Luxalon, Faneline Drumlin
35	Reflective glass	Glaverbel, Saint Gobain, Ashahi
36	Wood Polish	Sheentac, Asian

37	Granite	As per approved sample and BOQ
38	Acrylic Distemper	Berger, Asian, Nerolac, Jenson & Nickison
39	Cement Paint	Supercem, Snowcem
40	Stainless Steel	Jindal, SAIL
41	Ready Mix Concrete (RMC)	ACC, Unitech, Grasim
42	Locks at stations	Abloy Locks or Equivalent

ANNEXURE- A1C

IGBC Green New Buildings Rating System Checklist						
Likely	Strive for	Not Applicable	RSS		Points Available	Owner-occupied Buildings
Sustainable Architecture and Design					Data requirement	
1			SA Credit 1	Integrated Design Approach	1	- List of all the project team members and a brief on their contribution to the integrated design approach, along with the date of appointment/ award of contract to the project team members. - Minutes of Meeting (MoM) of at least three meetings held at different stages of the project, on green building design and construction aspects. - Photographs of the meetings held at different stages of the project.
		2	SA Credit 2	Site Preservation	2	- Narrative describing the strategies implemented to retain the site contour, existing water bodies, existing natural rocks, existing topography/ landscape, and to integrate existing trees with new development in the project. - Site survey plan/ Sectional drawings showing the retention/ preservation measures for each of the following site features, before and after development: - Site contour - Existing water bodies and channels - Existing natural rocks - Existing topography/ landscape, without any disturbance whatsoever - Calculations indicating the site features retained/ preserved, before and after development, in percentage. - Photographs showing the site features retained/ preserved, before and after development.

1		1	SA Credit 3	Passive Architecture	2	- List of the passive architectural measures implemented in the building. - Drawings and photographs (such as site plan, floor plans, sections & elevations, images, as applicable) showing the passive architectural features. Option 1: Simulation Approach - Simulation report indicating the energy savings achieved in the project through passive architectural features. Option 2: Prescriptive Approach - Narrative describing the strategies proposed to design passive architecture measures, as applicable. Exterior Openings (Projection Factor): - Calculations indicating the number of exterior openings (fenestration) having a Projection Factor of 0.5 or more to the total number of the exterior openings (fenestration), in percentage. Skylights: - Calculations indicating the roof area with skylights to the total roof area, in percentage. Passive Cooling / Heating Technologies: - Narrative describing the passive cooling / heating technologies, along with drawings and other supporting documents. Daylight: - Site/ master plan showing all the buildings. - Floor/ roof plans with window and skylight schedule. - Daylight simulation report with sky conditions (such as date & month; time;
2	0	3			5	
Site Selection and Planning						
Y			SSP Mandatory Requirement 1	Local Building Regulations	Required	- Site plan and as-built drawings (floor plans, elevations, sections, etc.,) approved by local Government authority.-received - Fit-for-occupancy certificate issued by local Government authority. - Photographs of the building taken at various stages of construction-pending

Y			SSP Mandatory Requirement 2	Soil Erosion Control	Required	▪ Narrative describing the Erosion and Sedimentation Control (ESC) measures implemented, during construction and post occupancy. ▪ Site drawing highlighting ESC measures implemented on-site, during construction and post occupancy. ▪ Photographs showing ESC measures taken at various stages of construction, before construction, during construction and post occupancy.
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1			SSP Credit 1	Basic Amenities	1	- Site vicinity map (with scale) highlighting the location of existing basic amenities, showing pedestrian access from the project. Note: For campus projects with multiple buildings, the compliance for basic amenities can be shown through one or combination of the following criteria: - From center of the campus/ zone - From entrance of the campus/ zone - Photographs showing the basic amenities.
1			SSP Credit 2	Proximity to Public Transport	1	Option 1: Public Transport - Site vicinity map (with scale) highlighting the location of intra-city railway station (or) a bus-stop, showing pedestrian access from the project. Note: For campus projects with multiple buildings, the compliance can be shown from entrance of the campus/ zone. - Photographs showing the intra-city railway station (or) a bus-stop. (Optional)
0	1		SSP Credit 3	Low-emitting Vehicles	1	- Calculations indicating the total number of occupants catered through electric vehicles/ CNG-powered vehicles in the project, in percentage. - Purchase invoice of the electric vehicles/ CNG-powered vehicles provided in the project. Electric Vehicles: - Calculations indicating the number of building occupants catered through electric vehicles/ CNG-powered vehicles in the project to the total number of building occupants, in percentage. - Parking layouts highlighting the location of preferred parking spaces with electric charging facilities for electric vehicles. - Photographs showing electric vehicles and electric charging facilities with signages, provided in the project.

						CNG-powered Vehicles: - Site vicinity map (with scale) highlighting the location of CNG filling station within 5 km distance (by road) from the project campus entrance. - Parking layouts highlighting the location of preferred parking spaces for CNG- powered vehicles. - Photographs showing CNG-powered vehicles and preferred parking spaces with signages provided for CNG-powered vehicles-Pending
2		SSP Credit 4	Natural Topography or Vegetation	2		Certification Option 1: Natural Topography and/or Vegetation: - Site drawing highlighting the area with natural topography (and /or) vegetation. - Calculations indicating the total area with natural topography (and / or) vegetation on the ground to the total site area, in percentage. - Photographs showing the site area with natural topography (and / or) vegetation. Option 2: Vegetation over Built Structures: - Site drawing and building roof plans highlighting the area with vegetation, as applicable. - Calculations indicating the total area with vegetation over the built structures to the total site area, in percentage. - Photographs showing the site area and building roof with vegetation.
1		SSP Credit 5	Preservation or Transplantation of Trees	1		- Narrative describing the strategies implemented to retain existing trees, transplant trees and plant new saplings, within the project site. - Site survey drawing highlighting the existing trees that are retained and/ or transplanted, within the project site. - Landscape drawing highlighting the preserved trees, transplanted trees and treesaplings. - Calculations indicating the total

						site area (in acres), number of preserved trees, transplanted trees and tree saplings. Photographs showing the existing trees (before construction) and preserved trees, transplanted trees and tree saplings (after construction).
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2		SSP Credit 6	Heat Island Reduction, Non-roof	2	▪ Narrative describing the strategies to reduce heat island effect from non-roof areas. ▪ Photographs showing the measures to reduce heat island effect from non-roof areas. Option 1: ▪ Site drawing highlighting the non-roof impervious (hardscape) areas and the areas covered with shade from tree cover within 5 years, (and/ or) open grid pavers, including grass pavers (and/ or) hardscape materials with SRI of at least 29 (and not higher than 64). ▪ Calculations indicating the area covered with shade from tree cover, (and/ or) open grid pavers, including grass pavers (and/ or) hardscape materials with SRI of at least 29 (and not higher than 64) to the total exposed non-roof impervious area, in percentage. ▪ List of the existing trees/ plant species which can mature into fully grown up trees for shading, within the next 5 years. ▪ If non-roof reflective materials sourced, provide the following: ○ Purchase invoice/ Payment receipt. ○ Manufacturer letters/ brochures indicating the Solar Reflective Index (SRI). Option 2: ▪ Calculations indicating the total number of parking spaces provided under cover to the total number of parking spaces, in percentage. ▪ Parking layouts highlighting the parking areas under cover.
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2	SSP Credit 7	Heat Island Reduction, Roof	2	▪ Narrative describing the strategies implemented to reduce heat island effect from roof areas. ▪ Photographs showing the measures to reduce heat island effect from roof areas. Option 1: High Reflective Materials ▪ Roof plans highlighting the area covered with high reflective roof materials. ▪ Roof area calculations indicating the total area covered with high reflective roof materials to the total exposed roof area (excluding service & utility areas), in percentage ▪ Purchase invoice/ Payment receipt of the high reflective roof materials sourced for the project. ▪ Manufacturer letters/ brochures indicating the Solar Reflective Index (SRI) of high reflective roof materials used in the project. Option 2: Vegetation ▪ Roof plans highlighting the area covered with vegetation in the project. ▪ Roof area calculations indicating the total area covered with vegetation to the total exposed roof area (excluding service & utility areas), in percentage. ▪ Declaration letter from the owner/ developer stating that the vegetated areas on the roof surfaces will be retained for life. Option 3: Combination of High Reflective Materials and Vegetation ▪ Roof plans highlighting the area covered with high reflective materials and / or vegetation installed in the project. ▪ Roof area calculations indicating the area covered with high reflective roof
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1			SSP Credit 8	Outdoor Light Pollution Reduction	1	▪ Narrative describing the strategies implemented for outdoor light pollution reduction and exterior LPD. ▪ Site drawing highlighting the exterior lighting fixtures. ▪ Calculations indicating upward lighting for each typical lighting fixture. The calculations shall include the lighting fixture type, quantity, total lumens, upward lumens and upward lighting percentage ▪ LPD calculations, along with the list of the exterior lighting fixtures (with make & model) proposed in the project. ▪ Photographs showing the typical exterior lighting fixtures.
0	1		SSP Credit 9	Universal Design	1	▪ Narrative describing the measures implemented in the building for differently abled people and senior citizens. ▪ Drawings highlighting the measures implemented for differently abled people and senior citizens. ▪ Calculations indicating the total number of preferred car park spaces (for differently abled people and senior citizens) to the total number of car park spaces. ▪ Calculations indicating the total number of rest rooms (toilets) provided in the common areas (for differently abled people and senior citizens) to the total number of building occupants. ▪ Photographs showing all the measures implemented. ▪ Manufacturer brochures for the measures implemented, as applicable.

1			SSP Credit 10	Basic Facilities for Construction Workforce	1	▪ Narrative describing the basic facilities provided in the project for construction workforce. ▪ Drawings highlighting the basic facilities provided for construction workforce. ▪ Calculations indicating the total number of construction workers and the total number of toilet seats & urinals provided in the project, for men and women. ▪ Extract of the construction contract agreement highlighting the facilities provided. ▪ Photographs showing the measures implemented.
1			SSP Credit 11	Green Building Guidelines	1	▪ Narrative describing the strategies adopted by the project team to create awareness among the building occupants/ tenants and the facilities team. Option 1: Owner-occupied Buildings ▪ Copy of the green building guidelines providing information which helps the building occupants to implement and utilise the green features, post occupancy. ▪ Copy of green building renovation guidelines providing information which helps the facilities team to implement the green features, during building renovation process.
12	0	2			14	
Water Conservation						
Y			WC Mandatory Requirement 1	Rainwater Harvesting, Roof & Non-roof	Required	▪ Narrative describing the strategies implemented to capture/ harvest rain water from roof & non-roof areas. ▪ Calculations indicating the run-off volume captured/ harvested from roof and non- roof. Notes: ▪ If bore well(s) are installed in the project to harvest rainwater, submit soil test report indicating the percolation rate(s). ▪ If rain water harvesting pit(s) are installed, then submit percolation rate(s). ▪ External storm water drain layout highlighting the location of rain water harvesting - ponds, pits,

					storage tanks, etc., as applicable, including cross-sectional drawings of rain water harvesting systems. ▪ If project's water is less than 4 meter, submit hydrology report (approved by third-party) indicating the level of water table, at different locations within the project site. ▪ Photographs of rain water harvesting systems, taken during and after construction.
Y			WC Mandatory Requirement 2	Water Efficient Plumbing Fixtures	Required ▪ List of plumbing fixtures (flow and flush) installed in the project, with respective make & model and flow rates. ▪ FTE occupancy calculations for the building occupants and visitors. ▪ Manufacturer cut-sheets/ brochures/ letters indicating the flow rates of the plumbing fixtures (flow and flush) at 3 bar flowing water pressure. Note: The manufacturer letters should be project specific. ▪ Purchase invoice of plumbing fixtures (flow and flush) with make & model. (On a case-to-case basis, assessor may request to submit purchase invoices)
2			WC Credit 1	Landscape Design	2 ▪ Landscape plan(s) highlighting the area covered with turf, drought tolerant species & other plant species, on the ground and over built structures. ▪ Calculations indicating the total landscape area (on the ground and over built structures) to the total site area, in percentage. ▪ List of turf, drought tolerant, native and adaptive species used in the project. ▪ Photographs showing the landscaped areas. Turf: ▪ Calculations indicating the area covered with turf (on the ground and over built structures) to the total landscape area, in percentage. Drought Tolerant Species: ▪ Calculations indicating the area covered with drought tolerant

						species/ native/ adaptive species (on the ground and over built structures) to the total landscape area, in percentage.
0		1	WC Credit 2	Management of Irrigation Systems	1	▪ Narrative describing the water efficient irrigation systems and techniques installed in the project. ▪ Landscape plan highlighting the irrigation systems, including soil moisture sensors. ▪ Manufacturer cut-sheets/ brochures of the installed water efficient irrigation systems and techniques. ▪ Photographs showing the installed irrigation systems and techniques.
4			WC Credit 3	Rainwater Harvesting, Roof & non-roof	4	Please refer to the Documentation required under WE Mandatory requirement 1- Rainwater harvesting, roof & non-roof.
5			WC Credit 4	Water Efficient Plumbing Fixtures	5	Please refer to the Documentation required under WE Mandatory requirement 2- Water Efficient Plumbing Fixtures.

3	2	WC Credit 5	Wastewater Treatment and Reuse	5	- Narrative describing the installed on-site waste water treatment system, along with the capacity & efficiency of treatment plant and the quality standards of waste water treated. - Daily and annual water balance of the project. Note: The water balance shall include calculations (approximate) showing the quantity of waste water generated & treated; water demand for landscaping, flushing and air-conditioning cooling tower make-up water (if the project uses water-cooled chillers), and quantity of waste water reused for such applications. - Calculations indicating the water requirement for landscaping, flushing and air-conditioning cooling tower make-up water (including evaporative losses, blow down losses and drift losses). - Site plan highlighting the location of installed on-site waste water treatment system. - Schematic drawing showing dual plumbing lines, if treated waste water is reused for flushing. - Photographs showing the on-site waste water treatment system installed.
1		WC Credit 6	Water Metering	1	- Narrative describing the water meters, installed in the project. - Schematic diagram showing the location of water meters, installed in the project. - Manufacturer cut-sheets/ brochures of the installed water meters. - Photographs of the installed water meters.
15	2	1		18	
Energy Efficiency					

Y		EE Mandatory Requirement 1	Ozone Depleting Substances	Required	- Declaration letter signed by the owner/ developer stating that the HVAC systems and fire suppression systems installed in the project are CFC free and Halon free. - Type of refrigerants installed in the HVAC systems. - Type of fire suppression systems installed in the project. - Manufacturer cut-sheet/ brochure of HVAC systems indicating the type of refrigerant and fire suppression systems installed in the project. - In owner-occupied buildings, if HVAC systems (including unitary air-conditioners) are not installed in the project, provide a declaration letter signed by the owner stating that no HVAC systems are installed in the project.
Y		EE Mandatory Requirement 2	Minimum Energy Efficiency	Required	Option 1: Performance Based Approach (Whole Building Simulation): - Building simulation analysis with the following information, as applicable: - Narrative stating the climate zone and the list of Energy Conservation Measures (ECMs) proposed in the project. - Comparison between the baseline building performance and the proposed building performance with percentage improvement. - The schedules for lighting power, thermostat set-point, HVAC system, miscellaneous equipment power, etc., for proposed building, as determined by the designer. - An explanation of any error messages noted in the simulation program output. - Details of the glazing proposed

					along with the list of identified manufacturers and respective specifications of glazing (SHGC value, U-value and VLT). Also, submit window-to-wall ratio (WWR) calculations for each building. ▪ Construction details of the wall proposed (including wall insulation material, etc.), along with the U-value of the overall wall assembly. - o Sectional drawings of wall assembly. ▪ Construction details of the roof proposed (including roof insulation material, etc.), along with the U-value of the overall roof assembly. - o Sectional drawings of roof assembly. ▪ Details of the lighting system proposed, including a list of interior and exterior lighting fixtures. - o Conceptual interior and exterior lighting layout. (Optional) - o Declaration letter signed by the project owner/ developer and lighting consultant indicating the proposed LPD. (On a case-to-case basis, the assessor may request to submit LPD calculation, as per building area method or space by space method.
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Y		EE Mandatory Requirement 3	Commissioning Plan for Building Equipments & System	Required	▪ Copy of an agreement signed between the owner and the third party commissioning authority, if applicable. ▪ Narrative describing the experience of commissioning authority, on similar projects. ▪ Owners brief in terms of performance expectations from the building. ▪ Commissioning plan describing how the building would be audited for its green building performance after occupancy, with regard to the following: ○ HVAC systems - chiller, VRV systems, primary & secondary water pumps, cooling tower, AHU fans, fresh air fans and flow settings, fresh air treatment units, heat recovery wheel, VFDs ○ Unitary air conditioners ○ Temperature and RH measurements in individual spaces ○ Pumps & motors ○ Lighting systems ○ Solar power systems ○ CO2 monitoring system ○ Energy & water metering ○ Building management system ○ DG sets ○ Sewage treatment plant ○ Any other equipment and systems ▪ Report specific observations and variations identified by commissioning authority to the project owner, for each equipment and system with respect to commissioning plan and how they were addressed. ▪ Measurement & verification plan for yearly reporting. ▪ Post-occupancy survey to verify occupants comfort (lighting levels, temperature, etc.)
1		EE Credit 1	Eco-friendly Refrigerants	1	▪ Type of refrigerants installed in the HVAC systems. ▪ Calculation indicating the combined contributions of the

						refrigerant installed in the HVAC system, to ozone depletion and global warming.
8	7		EE Credit 2	Enhanced Energy Efficiency	15	
4	2		EE Credit 3	On-site Renewable Energy	6	▪ Narrative describing the installed renewable energy systems, along with the technical details. ▪ Drawing showing the location of installed renewable energy systems. ▪ Owner-occupied-buildings: Calculations indicating the total annual energy generation from the on-site renewable energy systems (kWh) to the total annual energy consumption (kWh) of the building (interior & exterior areas), in percentage. Also, provide the details of capacity of the renewable energy system (kW). ▪ Tenant-occupied-buildings: Calculations indicating the total annual energy generation from the on-site renewable energy systems (kWh) to the total annual lighting energy consumption (kWh) of the building (interior & exterior areas) including tenant-occupied spaces, in percentage. Also, provide the details of capacity of the renewable energy system (kW). ▪ Purchase invoice/ Payment receipts of the installed renewable energy systems. ▪ Photographs showing the renewable energy systems.

		2	EE Credit 4	Off-site Renewable Energy	2	Option 1: Off-site Renewable Energy Investments ▪ Extract copy of contract agreement signed between the project owner/ developer [h^ nb_ al_h jiq_l ^_p_fij_l+ biabfiabniha nb_]igj[hs; ihp_mng_hn^_n[ifm ih i'', site renewable energy. ▪ Owner-occupied-buildings: Calculations indicating the total annual energy generation from the off-site renewable energy systems (kWh) to the total annual energy consumption (kWh) of the building (interior & exterior areas), in percentage. ▪ Tenant-occupied-buildings: Calculations indicating the total annual energy generation from the off-site renewable energy systems (kWh) to the total annual lighting energy consumption (kWh) of the building (interior & exterior areas) including tenant-occupied spaces, in percentage. ▪ Detailed report with technical details of the off-site renewable energy systems. Option 2: Renewable Energy Certificates (RECs) ▪ Owner-occupied-buildings: Calculations indicating the total annual energy generation from the off-site renewable energy systems (kWh) to the total annual energy consumption (kWh) of the building (interior & exterior areas), in percentage. ▪ Tenant-occupied-buildings: Calculations indicating the total annual energy generation from the off-site renewable energy systems (kWh) to the total annual energy.
2			EE Credit 5	Commissioning , Post-installation of Equipment & Systems	2	▪ Report specific observation and variation vis-à-vis the plan drawn under EC MR 2-commissioning plan for building equipment & system, identified during post occupancy commissioning and report how they were addressed. ▪ Copy of the contract agreement signed between the owner/ developer and the commissioning authority for a period of one year, to ensure that the commissioned equipment & systems perform efficiently.

2			EE Credit 6	Energy Metering and Management	2	Case 1: Energy Metering ▪ Narrative describing the energy meters installed in the project. ▪ Single line drawing showing the energy meters. Case 2: Building Management System ▪ Narrative describing that the building management system is in place to control and monitor the following systems, as applicable, along with the screen shots of live data: - o Air-conditioning management system - o Lighting management system - o Renewable energy management system - o Elevator management system - o Fresh air monitoring system - o CO2 control and monitoring system - o Water management system ▪ Declaration letter from the project owner/developer stating that the project will provide the annual total building energy consumption data to IGBC. The energy data shall be provided for all the major energy consuming equipment and systems.
17	9	2			28	
Building Materials and Resources						
Y			BMR Mandatory Requirement 1	Segregation of Waste, Post-occupancy	Required	▪ Narrative describing the strategies implemented to segregate and divert dry waste (paper, plastic, metals, glass, etc..) and wet waste from the building(s), to the easily accessible common facility. Also, describe strategies implemented to divert dry & wet waste and other waste such as batteries, e-waste, lamps and medical waste (if any), from the common facility. ▪ Floor plans showing the location of waste bins at floor level and common areas, as applicable. ▪ Site plan showing the location of the centralised facility for segregation of waste. ▪ Photographs showing waste segregation area, with waste bins and siganges.

6	2	BMR Credit 1	Sustainable Building Materials	8	Building Reuse: ▪ Narrative describing the strategies implemented to retain the structural and/or non- structural elements in the building. The narrative shall also include the list of structural and/or non-structural elements retained. ▪ Calculations indicating the structural and/or non-structural elements retained in the building (in terms of area) to the total structural and/or non-structural elements, in percentage. ▪ Photographs showing the structural and/or non-structural elements retained (before & after). Reuse of Salvaged Materials: ▪ Narrative describing the strategies implemented to source and reuse salvaged materials. The narrative shall also include the following: ◦ List of the salvaged materials and their applications. ◦ Source of salvaged material. ▪ Calculations indicating the salvaged materials sourced by the project (in terms of cost) to the total building materials cost, in percentage. ▪ Quotation/ Purchase invoice/ Payment receipts from vendors indicating the present market value (in terms of cost) of salvaged materials used in the project. ▪ Photographs showing the salvaged materials used (before & after). Materials with Recycled Content: ▪ Narrative describing the strategies implemented to source materials with recycled content. The narrative should also include the list of materials specifying recycled content, with manufacturer name. ▪ Calculations indicating the materials with recycled content (in terms of cost) to the total materials cost of the project, in percentage.
	2	BMR Credit 2	Organic Waste Management , Post- occupancy	2	▪ Narrative describing the strategies to handle kitchen waste & garden waste, and the on-site organic waste treatment system. ▪ Site plan highlighting the location of on-site organic waste treatment system installed in the project. ▪ Calculations indicating the quantity of organic waste treated in the project (including tenant-occupied areas) to the quantity of organic waste generated, in percentage. ▪ Manufacturer brochure/ cut-sheet of the installed organic waste treatment system. ▪ Purchase invoice/ payment receipts of the installed organic waste treatment system.

						Photographs showing the installed organic waste treatment system.
1			BMR Credit 3	Handling of Waste Materials, During Construction	1	- Narrative describing the strategies implemented to handle construction waste. The narrative shall also include the following: - List of construction waste materials generated and diverted for reuse, recycle & land-fill. - Applications of construction waste materials diverted for reuse, within or outside the project. - Site plan highlighting the construction waste management yard. - Calculations indicating the quantity of construction waste generated to the total quantity of construction waste reused, recycled and sent to landfill, in percentage. - Letters from scrap dealers stating the type and quantity of construction waste received from the project site, for recycling. - Letters from PST contractor s stating the type and quantity of construction waste reused in the project. - Photographs taken at various stages of the project showing the construction waste management.
	5		BMR Credit 4	Use of Certified Green Building Materials, Products & Equipment	5	- Narrative describing the strategies to source passive or active green building materials, products, and equipment, that are certified by IGBC under Green Product Certification Programme or by a third party agency approved by IGBC. The narrative should also include the list of passive or active green building materials, products, and equipment, with certification details. - Test certificates/ reports of the passive or active green building materials, products, and equipment.
7	5	4			16	
Indoor Environmental Quality						

Y		IEQ Mandatory Requirement 1	Minimum Fresh Air Ventilation	Required	Mechanically Ventilated Spaces ▪ Narrative stating the building's fresh air ventilation design in the project, as per ASHRAE standard 62.1-2010. ▪ Calculations indicating fresh air intake volumes in all regularly occupied spaces, for each zone. Non-Air-conditioned Spaces ▪ Floor plans with window and door schedule. ▪ Building elevations showing operable windows and doors. ▪ Calculations indicating the openable area of windows and doors to the carpet area, for each of the regularly occupied spaces in percentage. ▪ Photographs showing the operable windows and doors to the exteriors, in all the regularly occupied areas.
Y		IEQ Mandatory Requirement 2	Tobacco Smoke Control	Required	▪ Copy of 'no smoking policy' (or) Declaration letter from the project owner/ developer stating that 'smoking' will be prohibited in the project. ▪ Narrative describing the strategies implemented (eg. signages, posters, brochures, building guidelines, etc.,) to communicate 'no smoking policy' to all the building occupants/ tenants and visitors. ▪ If the building is designed with smoking rooms, provide the design details of the smoking room. ▪ Photographs showing 'no smoking' signages installed in the project and smoking room, as applicable.
1		IEQ Credit 1	CO2 Monitoring	1	▪ Narrative describing the strategies implemented to monitor CO2 levels in each zone. ▪ HVAC ducting layouts showing the location of CO2 sensors in return air ducts, for each zone. ▪ Technical specifications of the installed CO2 sensors. ▪ Purchase invoice/ Payment receipts of the installed CO2 sensors.

2		IEQ Credit 2	Daylighting	2	- Site/ master plan showing all the buildings. - Floor/ roof plans with window and skylight schedule. - Manufacturer brochure/ cut-sheet/ letter of the glass installed showing the Visual Light Transmittance (VLT). - Photographs showing the building elevations (all sides) and interiors spaces at different floors. Option 1: Simulation Approach - Daylight simulation report with sky conditions (such as date & month; time; ambient Lux levels) and wall, floor & roof reflectance properties, for all the regularly occupied spaces in the building. During simulation, consider shading devices and shadow effect of adjacent buildings. Option 2: Measurement Approach - Daylight analysis report indicating daylight illuminance levels measured at work plane height, for all the regularly occupied spaces in the building.
	1	IEQ Credit 3	Outdoor Views	1	- Site/ master plan showing all the buildings. - Furniture layouts of all the floors. - Sectional drawings indicating the direct line of sight to vision glazing, for each typical floor. - Calculations (floor-wise) indicating the regularly occupied spaces having access to outdoor views to the total regularly occupied space. - Photographs showing the outdoor views, for all the floors.
1		IEQ Credit 4	Minimise Indoor and Outdoor Pollutants	1	- Narrative describing the strategies implemented to minimise indoor and outdoor pollutants. - Plan highlighting the location of entry way systems at the building main entrance(s). - Floor plans highlighting the location of printer/copier rooms, chemical storage room, janitor rooms, AHU rooms etc., as applicable. - Details of exhaust system such as negative pressure maintained/ air changes/ exhaust rate. - Photographs showing exhaust system, self-closing door, deck-to-deck partition/ hard ceiling, MERV 13 or EU 7 filters and germicidal/ UV lamps, as applicable. - Purchase invoice of the MERV 13 or EU 7 filters and germicidal/ UV lamps, as applicable.

3			IEQ Credit 5	Low-emitting Materials	3	▪ Declaration letter from the project owner/ developer stating that the project will use low or no VOC content adhesives/sealants/paints. ▪ List of the proposed low or no VOC content (with make & model) proposed in the building interiors. ▪ Manufacturer cut-sheets/ brochures/ Materials Safety Data Sheet (MSDS) indicating the VOC content (in g/L, less water) of the adhesives proposed to be sourced.
1			IEQ Credit 6	Occupant Well-being Facilities	1	▪ List of occupant well-being facilities (such as gymnasium, aerobics, yoga, meditation or any indoor / outdoor games) provided in the project, with the location details. ▪ Plans highlighting the location of occupant well-being facilities. ▪ Calculations indicating the number of building occupants catered through occupant well-being facilities to the total number of building occupants, in percentage. ▪ Photographs showing the occupant well-being facilities
2			IEQ Credit 7	Indoor Air Quality Testing, After Construction and Before Occupancy	2	▪ Narrative describing the details of indoor air quality testing in regularly occupied and common areas of the building (after construction and before occupancy), including the test procedure followed. ▪ Indoor air quality test report for each of the regularly occupied and common areas.
1			IEQ Credit 8	Indoor Air Quality Management, During Construction	1	▪ Indoor Air Quality management plan describing the strategies implemented (during construction and pre-occupancy phase) addressing — scheduling, equipment & systems protection, housekeeping, isolating clean areas and source control. ▪ Photographs addressing IAQ measures taken at various stages of the project - construction, installation, commissioning and before

						occupancy of the building.
11	0	1			12	
Innovation and Development						
2	2		ID Credit 1	Innovation in Design Process	4	
	1		ID Credit 2	Optimization in Structural Design	1	
	1	1	ID Credit 3	Waste Water Reuse, During Construction	1	
1			ID Credit 4	IGBC Accredited Professional	1	
3	4	1			7	
			Total Maximum points			100
67	20	14	Certified 40-49 points, Silver 50-59 points, Gold 60-74 points, Platinum 75-89, Super Platinum 90-100 points			

ANNEXURE-A2AC DISTRIBUTION BOARD

Detailed Description of the Equipment & Its Application in RSS: Low Voltage Electrical Panels

- 1.1 The design, manufacturing , testing , installation and commissioning of complete 415 V, 3 phase, 4 wire and 50 Hz low voltage main switchboard is as defined in IEC/EN 61439-1, built up from compartments to house busbars, terminal blocks, internal and control wiring, instrumentation, relays, interlock and padlocking facility, emergency push buttons, equipment for 61850 compliant/SCADA /RS 485/ Mod bus connectivity of communicable ACB/MCCB interface, indication lamps, control and auxiliary switches, contacts, control power supply, air circuit breaker, MCCB, MCB, CTs and PTs, and any other items considered necessary to deliver the functions of incoming and outgoing power supplies.
- 1.2 Both the auxiliary transformers, with a capacity of 200 kVA are intended to supply the auxiliaries needed for operation of RSS, TSS and AMS equipment, as well as for the supply of the Auxiliary installation of these equipment. The low voltage AC Distribution Board has 2 incoming feeders from the 33 kV / 415 V Auxiliary Transformers, together with a Coupling Circuit Breaker. There are several 415 V or 240 V outgoing feeders for feeding the power required for lighting, fans, air conditioning, control and monitoring of switchgear etc in the RSS-cum-AMS-cum-TSS

Governing Specifications

Electrical Panels along with equipments shall conform to the latest standard or harmonize as per the respective standard as given below or specified along with the equipment in the specification.

In case of any conflict between specifications & the standards, the instructions/decision of the Engineer' or Employer's authorized representative shall be binding.

1. Technical and Installation Requirement 3.1

Description

Distribution of the low voltage circuits shall be provided with three specific cabinets, one for the half sub-station one, and the other for the half sub-station two, each supplied by the corresponding auxiliary transformer. These both cabinets are respectively called LVSB1 (Auxiliary Board 1) and LVSB2 (Auxiliary Board 2). The third one shall be dedicated to the coupling and to the supply of the rectifier two.

These cabinets shall be placed side by side to form a consistent assembly and shall be fitted, on their door, with a bar-type mimic diagram with signalling elements indicating the position of the main apparatuses. The LVSB1, LVSB2 and LVCSB cabinets shall each include a Master Circuit Breaker, plug-out type, lockable by lock and key. These Circuit Breakers are designated

as LVACB1, LVACB2, LVACCB. These Circuit Breakers are interlocked in such a way that normally only any 2 out of the three can remain in closed position at any point of time.

In normal operation LVACB1 and LVACB2 are closed, LVACCB is open. In case of voltage lack on one of the two bus bars, the relevant circuit breaker trips and the coupling circuit breaker closes with two (2) seconds delay to determine that there is real voltage lack (not to change for a temporary voltage drop).

At the coming back of the voltage, on the normal supply, the coupling circuit breaker shall trip with a delay of two seconds to ensure that the real voltage has come back, and the tripped circuit breaker shall close within 300 ms to ensure not to parallel both auxiliary transformers.

Operation of Low Voltage Distribution Board shall be realized by putting the system in Auto mode or Manual mode. Selection of Auto or Manual mode shall be possible through local/OCC SCADA. Similarly, selection of Local or remote mode shall also be possible through Local/OCC SCADA after selection on manual mode.

In addition, these Circuit Breakers shall be interlocked with the Auxiliary Transformer cubicle to ensure that

- > in case ACDB key is withdrawn, LVACB and corresponding LVATCB shall trip
- > it is not possible to open the door of the transformer cubicle if the LVACB of the particular transformer is in 'closed' position.
- > when, due to an overload on the downstream of the breaker **as per transformer capacity**, the LVACB **should** trip, and cause the corresponding 33 kV Circuit Breaker on the upstream of the particular transformer also to trip.
- > when, due to a 'Transformer fault' the 33 kV Circuit Breaker of the concerned transformer trips, it causes the corresponding LVACB also to trip.
- > If door of the transformer cubicle is opened with its key, it should trip the particular 33 kV Circuit Breaker and LVACB i.e. both side circuit breakers, in case any of these are in closed position.

3.2 Other Components

The LVSB1 and LVSB2 cabinets shall include the following (list is only indicative and not restrictive).

- > A master protection of 630 A, Four Pole, Circuit Breaker, Not less than 10KA Short circuit rating, plug-out type, lockable by lock and key
- > A set of four poles Tinned copper bus bar 1000A (short Circuit current 10 KA for 1 sec) for supply
- > A set of output circuit-breakers
- > The signaling contact on each apparatus
- > A specific outgoing for a battery charger
- > An interlocking device prohibiting paralleling.
- > Energy meter with summation CT on two incoming supply.

Similarly, the coupling LVCSB cabinet shall include the following.

- > A master protection of 630A, Four Pole, Circuit Breaker, Not less than

10KA Short circuit rating , plug-out type, lockable by lock and key

>A set of four poles Tinned copper bus bar 1000 A (short Circuit current 10 kA for 1 sec for supply.

As far as the outgoing feeders for control room AMS room and maintenance room lighting, fans, air-conditioning etc and those for 220/66/132/33/25 kV Switchyard, Traction & Auxiliary Main Transformer bays, 33 kV Switchgear 25 kV Switchyard, Battery chargers and for the 415 V distribution board requirements are concerned, the PST contractor shall provide adequate number of feeders to meet the full requirements. The details shall be submitted to the Employer, for his review and approval, by the PST contractor . However, the following is the minimum requirement in each of the LVSB1 and LVSB2 cabinets.

- a) 4 feeders each with 25A MCB, for Control Room & AMS Building lighting, fans with energy meter of accuracy class 1.
- b) 3 feeders each with 25A MCB, for **220/132/66 kV** Switchyard.
- c) 4 feeders each with 25A MCB, for Transformers OLTC.
- d) 2 feeders each with 25A MCB's for 33 kV Switchgear
- e) 2 feeders each with 25A MCB, for 25 kV Switchyard.
- f) 2 feeders each with 25A MCB, for Relay Panels.
- g) 2 feeders each with 100A TP MCCB's for Battery Chargers
- h) 4 feeders as spares with 3 feeders each with 25A MCB and 1 feeder with 32 A MCB.**
- i) 1 feeder of 125A FP MCCB for filtration machine with 125A three phase Industrial power socket **at firewall with suitable size of cable.**
- j) 1feeder each with 25A MCB for UPS**
- k) 1feeder each with 63A FP MCB for Air Conditioners with energy meter of Accuracy Class 0.2 1.
- l) 1 feeder each with 25A FP MCB for Yard Lighting with energy meter of Accuracy Class 1**
- m) 2 feeders with capacity according to the capacity of Solar Plant.

3.3 General and Technical Requirements of Electrical Panels

- > The Electrical Panel shall be same as low- voltage switchgear and control-gear assemblies defined in IEC 61439-1 or EN 61439 1 built up from compartments housing circuit breakers, control gear, relays, bus bars, controls and other equipment.
- > **As per IEC- 61439 The panels should comply to Design Verified Assemblies, wherein the verification is done by i) Testing, ii) Verification by Calculation/Measurement, iii) Verification by Design Rules, as per clause-10 of IEC-61439-1 (Latest). The tests should be carried out in government approved lab and should not be more than 5 years old from the date of issuance of vendor approval. The PST contractor shall submit complete record in support.**
- > **All the routine tests shall be performed in line of IEC 61439 and report shall be provided.**
- > The Electrical Panel shall pass the internal arc fault containment tests in accordance with IEC 61641 for fault current ratings for a minimum time of 0.3 sec.
- > The degree of Ingress Protection for Electrical Panels shall be IP-54, as defined in IEC 60529 which shall not deteriorate with time.
- > **The panel shall be suitable for Seismic withstand per IS 1893**

The same shall be tested at Govt. approved lab for seismic test and report to be provided.

- > The Electrical Panels and the associated equipment, including switchgear and control gear assemblies shall be certified for the category of duty specified as per Annex A of IS/IEC 60947-1.
- > The main circuit as defined in vide clause 3.1.3 of IEC 61439-1 shall have an insulation voltage of 1000 V AC.
- > **The ambient temperature and ambient humidity for Electrical Panel shall be as mentioned in GS of contract**
- > The Electrical Panels shall be a minimum of Form 4b Type 5 in accordance with IEC 61439-2. **Heat dissipation calculation in support of offered "Form" along with IP protection for barriers is to be provided as per the IEC.**
- > **Electrical panel shall have provision for top/bottom in-coming and bottom/top out-going to suit site conditions of cable entries.**

4. Low Voltage Switchgear:

4.1 Air Circuit Breakers

The moving part of incoming circuit breaker shall consist of a metal chassis fitted with an extraction system. This chassis shall carry a manually controlled four-pole circuit breaker with a current rating of 630 A. ACB should be mechanically robust of compact design, air break horizontal and withdrawable type, confirming to IS/IEC 60947-2 and EN 60947-2. The operating mechanism shall be trip-free.

Maximum number of circuit breaker auxiliary switches, spare auxiliary switches to be equally divided between normally open and normally closed. At least 4 spare pairs of N.O. and N.C. volt free contacts shall be provided.

The circuit breakers shall have sufficient breaking capacity to cut any short-circuit which could occur without suffering damage. They shall be fitted with:

- > Eight power connectors split down into two groups of four (inlet and outlet connectors),
- > A mechanical "closed" and "open" indicator (red and green)
 - > An interlocking system which prevents any movement of the chassis if the circuit- breaker is closed,

All ACBs shall be provided with interlocks to ensure that:

- > The ACB cannot be plugged in or isolated while it is closed,
- > The ACB cannot be closed until it is fully plugged in or completely isolated
- > The ACB cannot be closed in the service position without completing the auxiliary circuits between the fixed and moving portions
- > With manual charged and motor charged spring mechanisms the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected,
- > Facilities shall be provided for testing the ACB operation when in the isolated and withdrawn positions by the normal means as in service, and

> Where control circuits are provided and interlock circuits are broken via plugs on withdrawal of the ACB, a minimum of one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn position.

- > The neutral shall be rated for 100%
- > A lock which only releases the key when the moving section is unplugged and which engages in the fixed part,
- > A manual control system consisting of a lever that can be operated from outside,
- > A grounding system, which keeps the chassis ground during plugging-in until the power and monitoring connectors are engaged and which still ensures the chassis is grounded in the unplugged position.

Control switch for ACB shall be as follows:

Air Circuit breakers shall be fitted with operative switches of the pistol grip type. The handles of control switches for air circuit breakers shall turn clockwise for closing and anti - clockwise for tripping.

The control switch shall be clearly labelled as CIRCUIT BREAKER OPEN - NEUTRAL - CLOSE, with spring return to the neutral position. Mechanical interlock shall be fitted to prevent repetitive closing without moving first to the trip position, and shall be capable of padlocking in the neutral or trip position.

Voltage Monitoring

A voltage monitoring system shall be mounted upstream of the miniature circuit breaker on each main inlet. This system shall comprise:

- > A moving-iron voltmeter and a selector switch to select voltages across phases and between each phase and the neutral,
- > A 415 V indicator light protected by HRC fuses,
- > An On/Off voltage relay with a permanent power supply.

Current Monitoring

There shall be a current monitoring system mounted downstream of the main circuit breaker protected by **HRC** fuses. This monitoring system shall comprise three 5 A, 15 VA, class 1 current transformers each feeding a moving-iron ammeter.

Protections

ACB shall have microprocessor based protection releases for type of faults with selective over current (long time, short time & instantaneous) & earth fault protection, measurement of electrical parameters and with communication capability with SCADA system. ACB shall have an LED/LCD display to show true RMS current in all the three phases and highest current among these phases. The release shall be equipped with self diagnostic feature with indication. The release shall have zone selective

interlocking and IEC-61850 compliant. The protection characteristics should be front adjustable and password protected.

These shall be installed in, or on the front panel of the upper compartment together with the monitoring systems. They shall comprise:

- > auxiliary relays (alarms, voltage, ..., etc.),
- > test point boxes,
- > indicator lights and a "lamp test" push button,
- > selector switches and push button,
- > the fuses required to protect this equipment and the monitoring systems.

However, in general, all accessory equipment which contributes to the operation of a power switching component shall be mounted in the same cabinet as the component.

Auxiliary Power Supply

This shall be provided by a 110 V DC battery and charger system.

Selectivity

The protective systems shall provide optimum selectivity to ensure maximum continuity of the electrical power supply and to restrict any failures to their immediate area (in practice, this means that the values, curves and responses times of upstream protective systems shall always exceed those of downstream protective systems)

Electrical Characteristics

- > Rated Insulation Voltage: 1000 V
- > Rated Frequency: 50 Hz
- > Rated ambient temperature: As per IEC 60947
- > Rated service short-circuit breaking capacity (Ics): 100% of Icu
- > Rated short-circuit making capacity: shall be at-least 2.1 times of ultimate short circuit breaking capacity at 0.25 power factor.

Main Bus-bar of LVSB 1 & LVSB 2

These bus bars shall have a current rating of 1000 A

Short-circuits

The short circuit current value $I_{sc} = 10 \text{ kA}$ shall be used to select the dimensions of the main bus bar sets, the characteristics of the main low voltage circuit breakers and those of the protection equipment.

Manufacturing & Operating Principles

General

The equipment used in the cabinets shall consist of single insulation prefabricated units complying with IEC standard 157-1. The PST contractor shall supply a copy of the test report for the equipment.

The main inlets and outlets shall include compact plug-in circuit breakers designed such that the circuit breaker can be removed and replaced quickly without needing access to live parts. The contactors used in permanent board and permanent stand-by board shall be fixed.

Interchangeability

All moving components of plug-in units of the same type and with the same electrical characteristics shall be interchangeable.

Installation

The boards shall be installed in the technical rooms which house the 33kV bays and the 33kV / 415 V transformers they feed.

Structure

Each structure used in primary cabinets shall be listed and allocated an identification number to indicate its function (example: LVSB 1: Auxiliary Board 1).

The structure shall comprise:

- > The uprights,
- > The hardware,
- > The main bus bars,
- > The inlets and/or coupling bus bars,
- > The identification.

primary cabinet shall consist of three such structures:

- > One for LVSB 1
- > One for LVSB 2
- > One for coupling board LVCSB

Equipment

The boards shall comprise the following compartments, from the bottom:

- > A fixed compartment housing the monitoring systems and relays,
- > A plug-out compartment for the incoming circuit breakers,
- > A fixed compartment containing the protection equipment or the change-over switch gear between the two power supplies for the permanent stand-by cabinet,
- > The draw-out compartment(s) for the main outlets (> 63 A),
- > The fixed compartment for the other outlets,
- > And the terminal strips on the rear panel.

The boards shall be protected against fire by means of NOVAC system as per detailed specification given in the annexure-7. The keys for all LV cabinets and boxes shall be of the same type

Connection to Transformer

LVSB1 and LVSB2 shall be connected to the respective transformers, by 3.5 core Aluminium cables with 150 mm² cross section, per phase as well as neutral, shall be used for the connection.

Wiring

Only copper cable, multi-wire or single-wire cables, with a core cross section area of 1.5 mm² or more, shall be used for control and signaling wiring. All power connections shall be made at the bottom of the board. The terminal strips shall be designed to accept cables one gauge higher in cross-section than the cable used. Separators shall protect the strip against the danger represented by falling conductive objects.

Grounding

Frames shall be made electrically continuous by connection with copper bar, at least 30 x 3 mm size or 50x6 mm GI strip may be, provided for the grounding of the outlets. Door earthing shall be provided

with Green colour Copper flexible wire of minimum 2.5 sqmm size.

Remote Monitoring & Control

- > The following status and alarms for each Electrical Panels shall be sent to SCADA for remote monitoring on IEC 61850 standard protocol communication as approved but not limited to:
 - a. ACB open/close status,
 - b. Common alarm for ACBs trip on fault/lock out,
 - c. Common alarm for any Auto/Manual or local/remote or local/auto selector switch in local mode
 - d. Control supply failure,
 - e. ACB ready to close indication.
 - f. Emergency push button (EPB) operated, and
 - g. Busbar voltage ,current , frequency and energy parameter
 - h. Electrical Panels under voltage alarm and cause of tripping.
 - i. Provision of Selection of Manual/Auto control from SCADA.
 - j. Provision of close/open operation of ACBs from SCADA under manual control.

Relays

- > The relays are having in-built function with protective gears such as ACB, MCCB and MCB and MPCB etc. In case any relay is required for additional protection or otherwise, the same shall be provided to ensure full protection to the system.
- > O/L relay shall be adjustable type to meet the requirement, as per capacity of the Aux. LT transformer.

Emergency Push Button (EPB)

Emergency lock and key type push buttons shall be installed wherever required or specified to de-energize the Electrical Panels in the event of an emergency. The EPB shall be button type with flat surface protection guard ring and pressed- in design with key reset so that accidental triggering and vandalism shall be avoided as far as possible. Transparent hinged cover shall be provided in front. Unless otherwise specified on the Drawings, the EPB shall be mounted at 1300 + 100 mm above finish floor level. The button design and the installation details shall be submitted for approval.

2 Miniature Circuit Breakers (MCB)

MCBs shall comply with and be type-tested to IEC 60898 or EN 60898. **Type test report for the same shall be submitted.** MCBs shall meet the following requirements:

- > Number of poles: single-pole, double-pole, triple-pole or four-pole
- > Protection against external influences: Enclosed type,
- > Method of connection: Bolted type or clip-on type,
- > Rated operational voltage and frequency 240 / 415 V AC and 50 Hz.
- > Range of instantaneous tripping current: MCB's shall be current limiting Type **class to suit the requirement.**
- > Rated short-circuit breaking capacity: not less than 10 kA (M3) unless otherwise specified

- > I²t characteristic: suitable for load and circuit being protected,
- > Degree of protection: IP-20 for MCB's
- > Reference ambient temperature: as per IEC 60898.
- > The load handling contacts shall be silver/tungsten or proven material and the contacts and operating mechanism shall be designed so as to give a wiping action both at make and break. The breaker operating mechanism shall be of trip- free type. The breaker operating trolley shall be clearly indicated for the "ON" and "OFF" positions. It should be of Quick make and Quick break type.
- > Circuit protection against overload and short-circuit conditions shall be provided by means of thermal-magnetic device. Double-pole, triple-pole, and four pole MCBs shall be integral units and interlocked internally so that an over current through any pole shall trip all the poles of the MCB simultaneously. An assembly of two or three or four single-pole units mechanically strapped together is not acceptable.
- > Housing shall be heat resistant and having high impact strength. All DP, TP and FP circuit breaker shall have a common trip bar and should be mechanically coupled through a pin. It shall have an electrical endurance of the order of 10000 operation cycle for current rating of up to 50A.

4.3 Moulded Case Circuit Breakers (MCCB)

- > MCCBs shall comply with and be type-tested to IS/IEC 60947-2 or EN 60947-2. **Type test report for the same shall be submitted.**
- > Each MCCB shall be of fixed type and have all the mechanical and live parts completely enclosed in an insulated moulded case.
- > MCCBs shall meet the following requirements:
 - Number of poles: **single/double pole/triple pole/four pole**
 - Rated operational voltage: 240 / 415 V AC, as per drawing
 - Rated insulation voltage: **1000 V** AC, higher voltage acceptable
 - Rated uninterrupted current (In): as per capacity, but after taking into account the installation conditions and temperature deration.
 - Rated frequency: 50 Hz
 - **Rated ultimate short circuit breaking capacity (Ics)- should not be less than 10 kA**
 - **Ics should be equal to 100 % of Ics for the selected MCCB**
 - Rated short-circuit making capacity (Icm): shall be at least 2.1 times of ultimate short circuit breaking capacity at 0.25 power factor,
 - Utilization category: A or B as appropriate,
 - Degree of protection: IP 3X to IEC 60529 or EN 60529
 - Impulse Withstand Voltage - 8 kV
 - **Duty Cycle: CO-15 sec-CO**
 - MCCB's to be provided in LV Main Switchboard shall be fixed type with handle.
 - All MCCB's should have front adjustable microprocessor based releases with

adjustment in the range of 40 - 100% for nominal overloads and adjustable setting for short circuit faults. MCCB's for network/feeder Protection shall have releases with earth Fault Protection features.

- In case of 4 pole MCCB, neutral shall be defined and capable of offering protection upto full rating with possibility of adjustment at site in the neutral setting.
- Mechanical endurance shall be as specified in latest IEC standard.
- MCCB's shall have an electrical endurance operation cycles as per latest IEC standard 60947.
- All MCCB's shall be arranged for padlocking in OFF positions with lock provided.
- A shunt trip coil shall be provided to facilitate automatic tripping and local manual tripping. The manual trip device shall be fitted with the means of padlocking. The shunt trip coil shall be suitable for operation within a voltage range of 70% to 110% of the rated AC power supply voltage.
- Electronic trip units shall comply with the requirements as specified in Annexure- F (EMC /EMI Compatibility) of IEC 60947-2 or EN 60947-2.
- The trip unit shall be easily replaceable in the same MCCB without changing the MCCB.
- The time delay on overload tripping shall be inversely proportional to the over current up to a threshold value **decided as per selectivity of protection.**
- Handle position shall give positive indication of 'ON' 'OFF' or 'TRIPPED', thus qualifying to disconnection as per IEC 60947-3 indicating true position of all the contacts.
- The operating mechanism of MCCB's shall be Independent of the operating speed of the over centre toggle and the MCCB shall be of current limiting type and comprise of Quick make and Quick break switching. Contacts shall be non- welding type. The operating mechanism should be trip-free and provided with mechanical "ON", "OFF" and "TRIPPED" indicator.
- MCCB's shall have common field fittable auxiliaries for the entire range.
- **i) Door interlock to prevent door being opened when breaker is ON.**
- **ii) Interlock to prevent breaker being switched ON when door is open.**
- **4.4 Contactors**
 - > Contactors shall comply with IS/IEC 60947-4-1 or EN 60947-4-1.
 - > Contactors shall be electro-magnetically controlled, double air-break type.
 - > Contactors shall be four-pole, triple-pole, double-pole or single-pole.
 - > Contactors shall be silver-faced **or of proven material.**
 - > The contactor should be modular in design with minimum inventory requirements and

built -in mechanically interlocked wherever required. They should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors. The contactors from 4KW to 400KW shall be associated with the same 10 auxiliary contact block range.

- > The contactors for other applications shall have an un-interrupted rated duty and utilization category of at least AC3 at 415V and 50 Hz. The contacts should be of fast opening and fast closing type.
- > The making and breaking capacity values of the contactors should be as follows (as per IEC 60947-4)

For AC3 duty:

- > Making capacity equal to or more than 10 I_e
- > Braking Capacity equal to or more than 8 I_e , **For AC4 duty:**
- > Making capacity equal to or more than 12 I_e ,
- > Braking Capacity equal to or more than 10 I_e ,

- > The contactors should be capable of frequent switching and should operate without de-rating at 60°C for AC3 applications. They should be climate proof. The coil of the contactor should have class H insulation to support frequent switching. Class F insulation is also acceptable with the consent of the site Engineer.
- > The rated voltage of the contactor and the rated insulation voltage shall be 690V. The rated Impulse voltage of the contactor should be at least 8 KV.
- > Wherever DC control is required, the contactor should have wide range (0.7 to 1.25 U_c) DC coil with built in interference suppression as required.
- > They should be capable of being integrated into automated system (PLCs) without any interposing components in the minimum operating conditions.

4.5 Internal and Control Wiring

- > All equipment shall have adequate provision for the entry and termination of all **associated power and auxiliary cables.**
- > 1100 V grade FRLS copper flexible wire of 1.5 sqmm shall be used for control circuit and 6 sqmm for CT secondary circuit.
- > Wiring passing out to fully accessible positions shall be run in non-metallic low smoke halogen free flexible tubes or conduits.
- > All internal wiring shall be neatly run and securely fixed in non-metallic cleats in such a manner that, wherever practicable, wiring can be checked against diagrams without removal of the cleats.
- > Bus-wires shall be fully insulated. Bus-wires terminals shall be fully accessible from the point of entry to each enclosure. MCB and links shall be provided to enable all control circuits within the Electrical Panels to be isolated from the bus-wires.

- > All control circuits shall be protected by a MCB.
- > There shall be no joint in conductors between terminal points.
- > Terminations for terminals shall be of the crimped-on ring type. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.
- > Identification markers shall be fitted to all wires and multicore cable tails within enclosures in accordance with the diagram for apparatus concerned. Cable and core makers shall be of insulation material, a glossy finish, be resistant to oil and be incapable of supporting combustion. Numbers shall not be duplicated unless the corresponding wires are directly in series or parallel
- > Different insulation colours shall be provided to distinguish the various circuits. All wiring shall conform to the colour and ferrule codes to be approved by Engineer.

Auxiliary Switches and Contacts

- > Auxiliary switches provided for indication, protection, metering, control, interlocking supervisory purposes shall be readily accessible at the front of the Electrical Panels. Adequate secondary contacts shall be included to enable the auxiliary switch to be wired to the fixed portion of the equipment.
- > For each control compartment, spare auxiliary contacts with a minimum of two NO and two NC contacts shall be provided and wired to suitably identify spare terminals.
- > Auxiliary contacts for all applications shall be rated at 240 V AC or 110 V DC with contact rating of at least 6 A AC or DC and operating life of at-least one million on on-load operations at 0.4 power factor inductive load.

Finishes

- > Sheet Steel materials used in the construction of these units should have undergone a rigorous rust proofing process comprising of alkaline degreasing, de-scaling in dilute sulphuric acid and a recognized phosphating process. The steel work shall then receive two dip-coats of oxide filler/primer before final painting. Castings shall be scrupulously cleaned and fettled before receiving a similar oxide primer coat. The manufacturer is required to have 7 tank treatment facility for this.
- > All exposed metal surfaces, both internal and external, shall be thoroughly cleaned of all dust, oil, grease, scale, rust or any other contaminants and shall be epoxy powder coated immediately at the manufacturer's factory. In case of any doubt, the painting procedure, paint samples and process shall be approved prior to commencement of painting.
- > The epoxy powder coating shall be not less than 80 micron thick and with colour in accordance with BS 381C or BS 4800 as approved by Engineer.
- > Every care shall be taken to protect the surface of the panel from damages during transportation and installation. In case, there is any damage, the same shall be

made good by the method as approved by the site engineer which may also include change of the panel.

Nameplates and Labels

7.1 Name Plates

- > Each Electrical Panels shall have permanently attached to it in a conspicuous position labels upon which shall be engraved or stamped with the manufacturer's name, type and serial number, date of manufacture, designation of each Electrical Panels, details of the loading and duty at which the item of the Electrical Panels has been designed to operate. Such labels shall be of non- hygroscopic material.

7.2 Labels

- > Labels shall be provided for every panel to describe the duty of or otherwise identify every instrument, relay or item of control equipment mounted externally and internally.
- > The designation on these labels shall be clear and shall, where applicable, incorporate the device number along with concise descriptive wording in English.
- > Externally fitted panel labels shall be of perspex or other approved transparent plastic with letters and numbers rear engraved and filled with black.
- > Labels shall not be less than 45 mm high. Lettering shall be of not less than 10 mm high. All labels shall be securely fixed to the panels by bolts and nuts.
- > Circuit labels, one on the front of the panel and one on the rear of the panel suitably engraved.

Other Provisions

- > The Electrical Panels shall be provided with all necessary cable lugs etc., fixed in positions on mounting plates and straps, to suit the types and directions of entry of the cables as shown on the Drawings or as specified.
- > Cable conductors for all circuits within the Electrical Panels shall be arranged in a tidy manner and mechanically secured at regular intervals such that any movement occurring to the conductors, either under normal operation conditions (e.g. thermal expansion, vibration, etc.) or due to short circuit in any one of the circuits, shall not cause any damage or short circuit to any healthy bare live parts in the Electrical Panels.
- > Each Electrical Panels shall be supplied complete with all operating handles jigs, etc. required for the normal charging, closing, opening, racking in and out operations

of all circuit breakers of the Electrical Panels and shall be properly fixed in a neat manner on a board with brass hooks inside the switch room/plant room where the Electrical Panels is installed.

> Each Electrical Panels shall be provided with two nos. of rubber **insulating** mats of ribbed surface, complying to **IS-15652** or equivalent international standard. **The mats shall be** laid in front of and at the rear of the switch board. The rubber mats shall be continuous sheets of minimum thickness of 10 mm, each of same length as the switchboard and minimum width of not less than 1000 mm or the width of the space between the fronts or back of the switchboard to the adjacent wall.

Special Condition

> The Switchboard shall be complete with all components and accessories, which are necessary or usual for their efficient performance and satisfactory maintenance under the various operating and atmospheric conditions. Such parts shall be deemed to be included within the scope of supply whether specifically included or not in the specifications or in the tender schedules. The PST contractor shall not be eligible for any extra charges for such accessories etc.

Spares Details

> The manufacturer shall submit the list of spares which are required to be replaced as a must change item along with interval.

Material and Manufacturing

- > All similar items of the Electrical Panels and their component interchangeable.
- > Spare parts shall be manufactured originals and shall fit all similar items of the Electrical Panels. Where machining may be needed before fitting renewable parts, the machining fits and the associated tolerances shall be shown on the drawings accompanying the instruction manuals.
- > All parts which are susceptible to wear or contaminated by dust shall enclosed in dust-proof housings.
- > The style and finish of the workmanship shall be consistent throughout the Works.
- > Unless otherwise specified, Engineer shall decide the final colours for all paint work and other finishes to be applied to the Electrical Panels.

Testing

> Supplier shall submit MQP to Employer's engineer indicating quality hold points for approval to Employer's engineer.

Factory Acceptance Tests shall be carried out as per approved MQP plan.

Training

- > The PST contractor shall provide the following details
 - Every marshalling box and PLC compartment of the Electrical Panels shall

be provided with a wiring diagram suitably treated to prevent deterioration from dirt or age. The diagrams shall be drawn as if viewed from the point of access to the enclosure, and shall be securely fastened to the inside of the access door of that compartment.

- Bound booklet consisting of the details of the equipment
- Operating manual
- Warranty/DLP
- Purchase specification of maintenance spares
- List of staff trained
- Details of service centre.

ANNEXURE-A3
33/0.415KV DRY TYPE TRANSFORMER

33 KV / 415 V, 3 PHASE AUXILIARY TRANSFORMERS

The Auxiliary Transformers, also referred to as Auxiliary Station Transformers are required to supply the power requirement at 415 / 230 V of various electrical equipments, systems and appliances. Mainly these comprise of power required for lighting, fans, air-conditioning, Lifts, Escalators, Pumps, Signage boards, control and monitoring circuits, battery chargers, space heaters in the switchgear / panels etc.

This specification defines the main technical characteristics required for the 33000 / 415 V dry type transformers to be used in auxiliary substations (ASS), auxiliary main substations (AMS) or as required. This specification is applicable for the transformers of power rating of following capacity which are generally used in BSTP. This specification may be used for any other capacity in this range:

Transformer Capacity	
AN (Air Natural)	AF (Air Forced)
200 kVA	N/A
315 kVA	N/A
400 kVA	N/A
500 kVA	N/A
630 kVA	N/A
800 kVA	N/A
1000 kVA	N/A
1600 kVA	N/A
1600 kVA	2000 kVA
2000 kVA	N/A
2000 kVA	2500 kVA
2500 kVA	N/A
2500 kVA	3000 kVA
3150 kVA	N/A
3150 kVA	4000 kVA

The transformer offered shall be complete in all respects with all parts and accessories necessary for their efficient operation in sub stations. All such parts & accessories shall be deemed to be within the scope of this specification whether specifically mentioned or not.

2. GOVERNING SPECIFICATIONS:

The dry type auxiliary transformer shall conform to IEC 60076-11 with specified voltage as 33kV/415V.

2.1 STANDARDS

The transformer shall satisfy the following requirements and shall also comply with standards in force when the transformers are manufactured, particularly which are in the following table (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable): -

Standard #	Description
IEC 60076-3	Power transformers - Insulation levels, dielectric tests and external clearances in air
IEC 60076-11	Dry-type power transformers
IEC 60076-1	General power transformers,
IEC 60076-5	Ability to withstand short-circuit,
IEC 60076-12	Loading guide for dry-type power transformers,
IS 2026 - 5	Ability to withstand short circuit

2.2 ABBREVIATIONS

- IEC – International Electro technical Council
- IS - Indian Standard
- BS – British Standard
- ASS – Auxiliary Sub Station
- RSS – Receiving Sub Station
- GI – Galvanized Iron

3. **TECHNICAL REQUIREMENTS:** The details and specifications applicable to three phase 33 kV / 415 V auxiliary transformer are given below -

- (i) The primary and the secondary windings shall be capable of withstanding a symmetrical three-phase short-circuit regardless of the tapping selected. The short circuit level at secondary side for various ratings of transformers shall be as specified in the data sheet.
- (ii) The terminals shall be of the 36 kV type. Conductors insulated at 36 kV realize delta connection on primary side by using rigid conductors with suitable insulation sleeves. The secondary neutral shall be solidly earthed.
- (iii) This equipment shall satisfy all the requirements for interchangeability, interlock ability and functional control applicable to this type of equipment. It shall use a technology and components identical to those of the equipment to be installed in the Auxiliary sub stations.
- (iv) The Transformer shall be "Enclosed Dry Type Transformer" as per clause 3.3 of IEC 60076-11:2004, or as per latest updated version.

Characteristics :

Climatic conditions	indoor operation
Ambient temperature for design	50°C
Operation	Continuous
Windings	Aluminium for more than 200 kVA rating and Copper for 200 kVA & less rating

Primary line voltage (across phases)	33 kV
Secondary voltage, off-load	415 V
Primary Insulation rated voltage	36 kV
Frequency	50 Hz
Rated short duration separate source AC withstand voltage (r.m.s.)	70 kV (for HV winding), 3 kV (for LV winding)
Rated lightning impulse withstand voltage (peak value) (for HV winding)	200 kV
Connections	Dyn11
Cooling	Air natural/Air forced
Off load tap link (Not Required for 200 KVA or less rating transformers)	0, +2.5%, +5%

Overload Conditions	At least 10% for 2 Hours
Class of insulation for all windings	F Class for HV and LV winding
Climatic/Environmental/Fire Class	C1/E2/F1 (IEC 60076-11)

The magnetic circuit shall be in low-loss oriented-grain silicon steel sheet.

3.1 ACCESSORIES

- Installed on rollers/ base channels
- Lifting rings / Lifting Eyes
- 2 Nameplates - (1) on transformer, (2) on transformer enclosure
- Grounding terminal of Transformer frame, enclosure and Core
- Limit switches for enclosure doors as required
- Danger plates as per safety rules
- off circuit tap links with protection covers
- Fans with wiring upto scanner box, if applicable
- All the wires, control cables used shall be of FRLSH type, except in underground stations where it shall be FRLSZH type

The connection with different terminals of transformer shall be through C type or suitable connector for sufficient clearances from transformer windings HV connections of transformer shall be connected through insulated cables. HV terminals shall have suitable arrangement to provide sufficient clearance to 33 kV class cables from transformer windings and transformer enclosure as per IEC 60076-3.

3.1.1 All hardware like nuts, bolts, studs used should be of stainless steel.

3.1.2 The core shall be connected to earth.

3.2 TEMPERATURE PROTECTION

3.2.1 Transformers shall be fitted with a temperature protection system that allows winding temperatures to be monitored.

This shall consist of two sets of sensors placed inside each low-voltage winding to provide signals of Alarm and Trip and for fan operation. These signals to be used for Alarm and Trip of upstream circuit breakers, for fan operation, and also for indication in SCADA.

Temperature Sensor Relay should be installed in front side of the enclosure instead of front door of enclosure.

An indicator and relay with 6 inputs channel with RS 485 communication port as above shall be installed on the front side panel of the transformer enclosure, to indicate continuously the winding temperature.

Temperature sensor to be so designed to prevent any mal-operation due to dust.

- 3.2.2** The Temperature monitoring unit (TMU) shall be fixed in a separate housing fixed on the enclosure, which should prevent heat of transformer to directly affect the electronic components / circuit of TMU.

3.3 TRANSFORMER VALUES

The PST contractor shall confirm the following characteristics for each power distribution transformer:

- Short Circuit impedance (at 95°C and at principal tap with +/- 10 % tolerance as per IEC / IS.)
- No-load losses (Maximum),
- Full-load losses at 95°C (Maximum)
- Efficiency at 95°C at different load conditions:

Full load: Power factor = 1 (Minimum efficiency: 98.4%)

Power factor = 0.8 (Minimum efficiency: 98%) The efficiency of transformer at 1/4, 1/2, 3/4, full load at unity and 0.8PF for these loads shall be more than 98%. Bidder in the offer shall meet the conditions of efficiency as above.

3.4 TRANSFORMER CUBICLE

- 3.4.1** Transformers shall be installed in dismountable cubicle, made up of sheet steel of minimum 2 mm thickness, Powder coated with provision of wire-mesh.

The transformer enclosure shall be provided with cut out openings. The transformers shall be supplied in a cubicle with enclosure and without any HV portions exposed.

These Ventilation openings shall be provided all around on the transformer enclosure with sufficient open area to dissipate the heat released by transformer.

The door shall be provided with a mechanical interlocking system, to ensure that it is possible to open the door only when the protection circuit breakers on the HV side as well as LV side of the transformer are in 'open' position and Earth switch on upstream 33 kV cable is closed. Also circuit breakers on

the HV side as well as LV side of the transformer should trip if somebody tries to open the door without opening the HV & LV side breakers.

Minimum Clearance of any earthed part or enclosure from any live terminal of transformer should be as per IEC 60076-3. Apart from this 500 mm clearance shall be maintained between any part of the transformer and its enclosure for ease of movement during O&M.

The transformer should be tested with enclosure in temperature rise type test. Temperature rise test shall be done with enclosure designed and intended to be used for the particular type of transformer. The enclosure supplied shall be similar as used in the temperature rise test.

Enclosure shall have inspection windows of minimum size of 400 mm x 400 mm on both sides to view primary & secondary sides of the transformer. LED Lights (10 Watts) inside transformer enclosure on both HV and LV sides shall be provided for visual inspection from outside. Switch should be provided on outer side of the enclosure to operate the lights.

The cubicle shall have space for installation of snubber circuit and Surge Arrester on HV side of transformer.

The cubicle shall provide protection against direct contact with the power transformer. It shall include connections for the HV lines from the protection bay and connections for the low voltage circuit.

The transformer enclosure shall be designed and provided by the transformer manufacturer along with the transformer.

3.4.2 Cable arrangement shall facilitate the exchange of either of the transformers without any difficulty, i.e. the cables shall be laid along each side and connected to the transformer in such a way that it will not block the passage for removal of any of the transformer during service. The PST contractor will provide suitable size stiffeners in enclosure for connection of bus duct and to ensure that the enclosure does not deform due to Bus duct connection. The panel shall not make any rattling sound and should be provided with a rubber gasket as required.

3.4.3 Automatic fire detector and extinguisher system:-

'Automatic fire detector and extinguisher system' shall be provided in line with integrated fire suppression system of substation, and the provisions required, if any, shall be done by Transformer manufacturer.

The cubicles shall be protected against fire by means of an 'automatic fire detector and extinguisher system', 'based on Aerosol' approved by Chief Controller of Explosives, valves, flexible detection and delivery system in the form of a flexible tube made of special polymer, capable of withstanding normal pressure and maximum pressure as

per design of the system and applicable standards, suitably routed inside the transformer enclosure for detection of fire. The system shall be suitably mounted on the Transformer enclosure or on the floor near the transformer enclosure and shall be capable of flooding the cubicle within the shortest response time, not more than 10 seconds after the fire is sensed by the flexible detector tube. The PST contractor shall submit the complete technical data of the system and shall obtain the approval of Employer's engineer before ordering for manufacture of transformer enclosure.

3.4.4 The bimetallic strip required for connection in any case shall be provided by the PST contractor .

3.4.5 The Transformer enclosure shall be provided with earthing connections by routing and connecting earth strips (suitably sized as per LT side fault level, but minimum GI Strip of 50 X 5 mm), and connected to all the panel sheets of the enclosure.

Above Earthing strips should be provided on suitable support arrangement fixed horizontally & vertically running along the inside of enclosure.

3.4.6 Entry inside the transformer enclosure should be blocked and all the trenches/cable entry openings etc. on the transformer enclosures should be sealed to avoid any entry of rodents / lizards / insects etc.

3.5 TERMINAL ARRANGEMENTS

The terminal arrangements for high voltage side shall be suitable for required size of cables. The terminal arrangement for Low voltage side shall be suitable for required size of cables/Bus ducts. Suitable arrangements shall be available for cable terminations so that the cable/Bus duct weight doesn't come on the terminals.

The terminals on the primary side should be provided with proper protection against creepage suitable for 36 KV.

3.5.1 The clearances of transformer HV side terminals shall be **more than 500mm** as per IEC 60076-3. The manufacturer shall submit the transformer drawings showing all the clearances and dimensions.

3.5.2 The provisions shall be made for the earthing connection of cable sheath for both HT and LT sides.

3.5.3 LV side terminal clearance: -

For the LV (415 V) terminals or bars, the clearances and creepage distances in Air, shall not be less than as specified below: -

Minimum Clearance & creepage distances between Phase to Phase in Air*	Minimum Clearance & creepage distances between Phase to Neutral / core / core frame / earth in Air*
25 mm	20 mm

* However, for safety purpose, Fire retardant Insulation tape of 1.1 kV strength should be provided on the phase terminal bars of the transformer on LV (415 V) side,

wherever gap in air between phases to neutral is less than 50mm.

The Neutral terminal bar shall be preferably towards core / core frame, and the Phase terminal bars shall preferably be away from core / core frame.

3.5.4 There should be "No exposed" conductors or exposed live parts. All HV and LV terminals shall be protected/covered suitably with shrouds/tapes of corresponding voltage rating. Painted bus bars are preferred, which should be suitable for transformer design and service conditions.

3.5.5 33 kV Cable connections:- The 33 kV cable used for connection from 33kV CB to HV(33 kV) terminals of Transformer inside ASS shall be of at least 300 sq.mm. or higher size, similar to 33 kV cable used in main line between ASS to ASS.

3.6 PAINTING

All steel surfaces shall be powder coated with average 120 micron thickness, which shall be suitable for heavily polluted atmosphere and shall be of color RAL 7032.

3.7 INSULATION OF WINDINGS

- > HV windings should be cast resin moulded type, and
- > LV winding shall be of pre impregnated with top and bottom properly sealed by resin to protect from dust and moisture ingress/ or it may be cast resin moulded type.

Insulation barrier sheet between LV and HV windings with appropriate clearance shall be provided for full height of windings. The insulation barrier must be fire proof, and fire retardent.

3.7.1 Identification of winding coils:- Each of the 33kV windings coils shall have identification name plate (sticker or engraved) with details of coil number, Transformer Sl. no., voltage, capacity, date of casting, manufacturer, etc. for traceability.

3.8 NAME PLATE DETAILS

3.8.1 Rating Plate fitted to the transformer

Each transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the items indicated below. The entries on the plate shall be indelibly marked (i.e. by engraving, stamping or by a photo chemical process).

- a) Dry type transformer
- b) Standard, Number & year of latest IEC 60076
- c) Manufacturer's name
- d) Manufacturer's serial number

- e) Year of manufacture
- f) Insulation system temperature for each winding. The first letter shall refer to high voltage winding, the second letter shall refer to low voltage winding.
When more than two windings are present, the letters shall be placed in the order of windings from the high voltage to low voltage
- g) No. of phases
- h) Rated power for each kind of cooling
- i) Rated frequency
- j) Rated voltages, including tapping voltages, if any
- k) Rated currents for each kind of cooling
- l) Connection symbol
- m) Short circuit impedance at rated current, rated voltage and at the appropriate referenced temperature (it shall be the measured value during FAT)
- n) Type of cooling
- o) Total mass
- p) Insulation levels
- q) Degree of protection
- r) Environmental class
- s) Climatic class
- t) Fire behaviour class

The rated withstand voltages for all windings shall appear on the rating plate. The principles of the standard notation are illustrated in clause 5 of IEC 600763.

3.8.2 Rating Plate fitted to the transformer enclosure

Each transformer enclosure shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the items shown in 3.8.1 The entries on the plate shall be indelibly marked (i.e. etching, engraving, stamping or by a photochemical process).

3.9 CAPITALIZATION AND PENALTY

The transformers shall be designed for minimum losses. When comparing between different tenders the present value of the capitalized cost of losses in the transformers shall be added to their financial bid by the following formula $PW = K * 365 * 24 * C (W_{ir} + b^2 W_{cu}) / 1000$

Where

- PW is the present worth (in INR) of annual capitalized cost of losses at 8% rate of interest over 25 years
- K is the present worth factor (8% interest, 25 years) = $\{(1+0.08)^{25} - 1\} / \{0.08 * (1+0.08)^{25}\} = 10.675$

- **C is the cost of the kWh (in Indian Rupees) = Rs. 6.60(or actual present tariff rate)**
- Wir is the iron losses in Watts at normal voltage and main tapping
- Wcu is the full load losses in Watts at normal voltage and main tapping at 95°C
- b is the load factor of transformer = 50 %

Thus $PW = 10.675 \times 365 \times 24 \times 6.60 (Wir + b^2 Wcu) / 1000$

$PW = 617.18 (Wir + 0.25 Wcu)$

In case the transformer losses during tests are found greater than the values guaranteed in the offer, a consolidated penalty shall be paid by the PST contractor, according to the following formula (any tolerance from the declared value on upper side will not be considered):

$617.18 (dWir + 0.25 dWcu)$ Where,

- dWir and dWcu are the differences between the test values of iron losses at full voltage and and full load loss at full load on one transformer at main tapping and the values guaranteed in the offer.

3.10 TRANSIENT OVERVOLTAGE PROTECTIONS: -

PST contractor to carry out System study using EMTP, simulation and measurements, for ascertaining the over voltages due to transients at the terminals of Transformer. Suitable measures and protection for Transient over voltages should be worked out **for different length and size of cable** and provided for the Transformer protection, with the approval of Employer's engineer.

3.10.1 Surge Arresters/Snubber circuit:- Surge Arresters/ RC Snubber circuit shall be provided between Phase - Phase, and Phase - Earth, on all three phases, of suitable rated values on 33 kV side of Transformers. The surge counters for each Surge arrester should be provided. PST contractor to verify the rating of surge arrester for suitability **based on the study in Para 3.10 above** and obtain approval of Employer's engineer.

3.10.2 Snubber circuit and surge arrestors of suitable ratings at the HV terminal of Transformer to be provided.

3.10.3 Transformer Insulation:- The insulation of Transformer should be so designed and provided to be able to sustain the Transient over voltages in the 33 kV system.

The PST contractor should study the Transient over voltages expected in the system, and the insulation of Transformer should be designed accordingly.

3.10.4 The Transformer may be proposed to be provided with any other alternate protection measures against transient over-voltages subject to a proven solution and its approval by Employer's engineer.

3.10.5 Any damage due to fast switching events shall be covered under the manufacturer's standard warranties.

3.11 TRANSPORTATION AND PACKAGING: -

3.11.1 The transformer to be supplied in weather proof sea worthy proper packing to prevent any dust, moisture or any physical damage.

4. MAINTENANCE & LIFE

The transformer should be designed for best service life in the industry (Approx. 40 years) for all types of installation & under prescribed environmental conditions.

4.1. The Transformer to be kept clean.

The installation of transformer should be carried out in clean environment i.e. free from dust, debris etc. It should be ensured that the transformer should be kept clean in all conditions during the storage, installation, after charging, before hand over and during DLP.

During Project phase till handover, regular cleaning of the transformer is the responsibility of PST contractor .

5. DATA SHEET - AUXILIARY TRANSFORMERS**5.1 AUXILIARY TRANSFORMER 200 KVA, 500 KVA AND 630 KVA**

S.n	INDICATIONS	U	VALUES Required		
			200 KVA	500 KVA	630 kVA
1	Manufacturer				
2	Place of manufacture				
3	Port of embarkation				
4	Manufacturer drawing reference				
5	Standards		IEC 60076	IEC	IEC 60076
6	Rated power	kVA	200	50	630
6	Cooling mode		AN	A	AN
7	Primary rated insulation voltage	kV	36	36	36
8	Primary operating voltage	kV	33	33	33
9	Secondary rated operating voltage	V	415/240	415/240	415/240
10	Rated short duration power frequency withstand voltage for primary winding	kV	70	70	70
11	Rated lightning impulse withstand voltage for primary	kV	200	200	200
12	Short-circuit impedance (Cl. 3.3)	%	4	4	4
13	Short circuit current on secondary side	kA	6.9	17.4	21.9
14	Voltage setting (Off load tap links)	%	+5.0, +2.5, 0, -2.5, -5.0	+5.0, +2.5, 0, -2.5, -5.0	+5.0, +2.5, 0, -2.5, -5.0
15	Vector Group		Dyn11	Dyn11	Dyn11
16	Maximum noise level	dBA	65 dB at 1.5 metres	65 dB at 1.5	65 dB at 1.5 metres
17	Class of Insulation		F	F	F
18	Maximum iron losses	W	1050	1700	1950
19	Maximum load losses	W	2500	4800	5100

			defined in Specifications)	defined in Specifications)	defined in Specifications)
20	Dimensions (maximum)* - Length - Width - Height	mm mm mm	2000 1500 2250	2000 2000 2250	2000 2000 2250
21	Weight (maximum)*	Kg	1700	2600	3000
	*Dimensions and weight shown are indicative only				

5.3 AUXILIARY TRANSFORMER 2500/3000 kVA, 3150 kVA and 3150/4000 kVA

S.no.	INDICATIONS		U	
				2500/3000 kVA
1	Manufacturer			
2	Place of manufacture			
3	Port of embarkation			
4	Manufacturer drawing reference			
5	Standards			IEC 60076
6	Rated power	AN		2500
		AF		3000
7	Cooling mode			AN
				AF
8	Primary rated insulation voltage		kV	36
9	Primary operating voltage		kV	33
10	Secondary rated operating voltage		V	415/240
11	Rated short duration power frequency withstand voltage for primary winding		kV	70
12	Rated lightning impulse withstand voltage for primary winding		kV	200
13	Short-circuit impedance(Cl. 3.3)		%	6
14	Short circuit current on secondary side		kA	58
15	Voltage setting (Off load Tap Links)		%	+5.0, +2.5, 0, -2.5, -5.0
16	Vector Group			Dyn11
17	Maximum noise level		dBA	65 dB at 1.5 metres 75 dB at 1.5 m for AF
18	Class of Insulation			F
19	Maximum iron losses		kW	3.70
20	Maximum load losses		kW	15

21	Dimensions (maximum)*		
	- Length	mm	2100
	- Width	mm	2900
	- Height	mm	2250
22	Weight (maximum)*	kg	7000

*Dimensions and weight shown are indicative only

6. TEST SHEET

6.1 AUXILIARY TRANSFORMERS

All Tests shall be performed on a completely assembled transformer including relevant accessories supplied.

All routine tests as per IEC 60076-11 are to be conducted including Partial Discharge during Manufacturer's Internal test & Factory Acceptance Test on all completely assembled transformer.

All type tests as per IEC 60076-11 shall be conducted on one transformer for each rating and make before supply to BSTP.

All the type tests shall be conducted on each rating of the transformer separately.

Central Electricity Authority (technical standard for construction of Electrical Plants and Electric Lines) regulations 2010, has made the short circuit testing mandatory. Short circuit withstand test shall be conducted on one of each type, rating and make of transformer to validate the design and quality unless such test has been conducted. The test shall be conducted before making any supply to BSTP.

The relevant regulations No. are 10(3)(g), 37(4)(k), 43(2)(a)(vi), which are available on CEA's website www.cea.nic.in.

In view of above the supplier shall subject the transformer to a short circuit test as per relevant IEC/IS standard meeting the requirement of above mentioned regulations of CEA.

6.2 PARTIAL DISCHARGE TEST

Partial Discharge Test shall be conducted on all the transformers in fully assembled condition during the routine tests. The maximum level of Partial Discharges shall be 10 pC as per IEC 60076-11 (2004) or updated as per latest IEC.

6.3 ENVIRONMENT, CLIMATE & FIRE BEHAVIOUR CLASS

To establish above classes, Transformer should to be tested As per IEC 60076-11, and reports should be submitted along with the vendor approval. The dry type transformer shall be rated for following classes –Environment Class E2, Climatic Class C1/C2 and Fire behaviour Class F1 -

Transformer only from the proposed manufacturing unit to be type tested, and confirmation certificate by Design head and unit head, for similar material and design used in other transformers to be submitted. *This certificate shall be treated as corporate warranty for any damages on this account.*

Class E2: Frequent condensation or heavy pollution or combination of both.

Class C1: The transformer is suitable for operation at ambient temperature not below – 5°C but may be exposed during transport and storage to ambient temperatures down to – 25°C.

Class F1: Transformers subject to a fire hazard. Restricted flammability is required. The emission of toxic substances and opaque smokes shall be minimised.

6.4 MEASUREMENT OF SOUND LEVEL (SPECIAL TEST)

Measurement of Sound Level test (special tests as per IEC 60076-11) shall be conducted during Manufacturer's Internal test & Factory Acceptance Test on all transformer using sound pressure level technique. The testing shall be conducted on a completely assembled transformer including relevant accessories supplied.

6.5 TEMPERATURE RISE TEST:-

The transformer should be tested with enclosure in temperature rise type test. Temperature rise test shall be done with enclosure designed and intended to be used for the particular type of transformer. The enclosure supplied shall be similar as used in the temperature rise test.

The temperature rise limits shall be as per IEC 60076-11, for example, for class F insulation, Temperature Rise shall be limited to 90 Deg C above ambient temperature of 50 Deg C.

The Temperature rise test of Transformer shall be conducted considering the transformer as "Enclosed Dry Type Transformer" as per clause 3.3 of IEC 60076-11:2004.

6.6 CHOPPED WAVE LIGHTNING IMPULSE TEST FOR LINE TERMINALS (LIC) (SPECIAL TEST): -

Chopped wave Lightning Impulse test for Line terminals (LIC) (Special test) shall be conducted as per IEC 60076-3 on all the windings, for one transformer of each type of kVA rating, being supplied in the contract.

The test voltage for LIC test shall be 220 kV for 33 kV (Um=36 kV) windings.

The test report of previously conducted LIC test on exactly similar transformer shall be valid if not older than 5 years.

Test should be conducted with transformer enclosure assembly installed

ANNEXURE-A4**INVERTERS FOR RECEIVING SUB STATION (RSS)**

The substation automation system works on 110 V DC and 230 V AC single phase supply. 110 V DC shall be given to all Control and Protection relay, Ethernet switch and associated equipment through the three nos. battery charger (two main + one standby) and two nos. of 110 V battery set. 230 V AC supply to substation Automation equipment like servers, gateway printer, HMI and other associated equipments shall be given through the inverter.

Input supply to the inverter shall be 110 V DC from the existing battery sets available in the RSS. These batteries shall be charged by battery charger in float mode, as well as in boost mode. During normal operation input supply to the inverter shall be taken from the battery set and inverter will give 230 V AC supply without any interruption to Substation Automation equipments, in case of the failure of one inverter second hot standby inverter shall take full load. In the event of power failure, necessary safeguards software shall be built for proper shut down and restart.

1. Governing Specifications**2.1 Standards**

The inverter shall satisfy the following requirements and shall also comply with standards in force when the inverters are manufactured, particularly as mentioned in the following table (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable):

Standard #	Description
IEC 62040	Uninterruptible power systems (UPS)

2.2 Abbreviations

- IEC – International Electro Technical Council
- HMI – Human Machine Interface
- RSS – Receiving Sub Station

3. TECHNICAL REQUIREMENTS**3.1 Operation Philosophy**

The inverter shall comprise of following components/equipment along with 100% standby inverter with same set of components/equipment:

- one Inverter
- one static bypass switch
- one Maintenance Bypass switch
- one AC output protection circuit breaker

During normal operation inverter will draw power from battery and load on the inverters will be shared equally by both the inverters. In case of failure of one inverter, the second standby inverter shall take over the complete load. Further, in case of failure of both the inverters, power will be supplied to load by thyristors switches automatically, without breaking, on the stand by supply made through distribution board.

For maintenance purpose or in case of failure of both the static switches, the supply of the connected equipment will be ensured by Maintenance bypass Switch with the following operations:

- > Automatically in case of standby supply static switch failure. This transfer shall be made with a maximum delay of 20ms. In such a case, the coming back to the normal situation, after repair, shall be only manual without breaking.
- > Manually for maintenance purpose. This transfer shall be made without breaking in the both ways.

3.2 Equipment Environment

The following are the minimum requirements for inverter equipment to be installed in below mentioned class of environment:-

- a) Ambient Temperature- as per GS
- b) Maximum Temperature- as per GS
- c) Relative Humidity- as per GS
- d) Chemical Environment Factor- 3C3 as per IEC 60721-3-3
- e) Air Quality- Polluted and dusty, Suspended Particulate Matter 360-540 mg/m³ as per GS
- f) Electric Noise- Impulse 1kV, 1.2/50 rise/decay, 500 Ω source

impedance, 0.5 J source energy

g) Radio & High Frequency as Class A.

4. Special Conditions

Only industrial grade components shall be used in the inverters to ensure the proper working of equipment under temperature range of -5°C to 85°C. All electronic cards shall confirm to environment factor class 3C3 as per IEC 60721-3-3 for highly Polluted area. Cards must have conformal coating confirming with IEC 60815 - 1996 and tested for H₂S, SO₂ and mixed gas tests as per IEC 60068 - 1 & 2.

5. Maintenance & Life

The inverters should be designed for best service life in the industry for all types of installation & under prescribed environmental conditions.

6. Data Sheet

The Inverter shall comply with the following characteristics:

Standards	IEC 62040	
1) ELECTRICAL CHARACTERISTICS		
Type		Indoor
Rated power (at cos φ = 0.8)	KVA	3.0
Input voltage	V	110V DC
Input voltage variations	%	+10, -15
Bypass Input	V	230V AC
Bypass voltage variations	%	+10, -15
Bypass frequency	Hz	50
Bypass frequency variations	%	±5
Output voltage	V	230 AC
Output voltage variations	%	±1
Output frequency	Hz	50

Output frequency tolerance	%	0.5
Harmonic content of output voltage	%	3
System efficiency	%	90
IP protection		31
Cable entry		Bottom
Cabinet Panel Color		RAL 7032
Static Bypass		Electronic Thyristor Switch
Manual Bypass		MCB

Control and Monitoring Signal for SCADA

Following control and monitoring signals from the inverter shall be required on SCADA

Sl. No.	Origin	Information
1.	Inverter-1	On Indication
		Off Indication
		Inverter Fail
		Inverter Static Bypass
		Inverter Manual Bypass
		Input Voltage
		Output Voltage
2.	Inverter-2	On Indication
		Off Indication
		Inverter Fail
		Inverter Static Bypass
		Inverter Manual Bypass
		Input Voltage
		Output Voltage

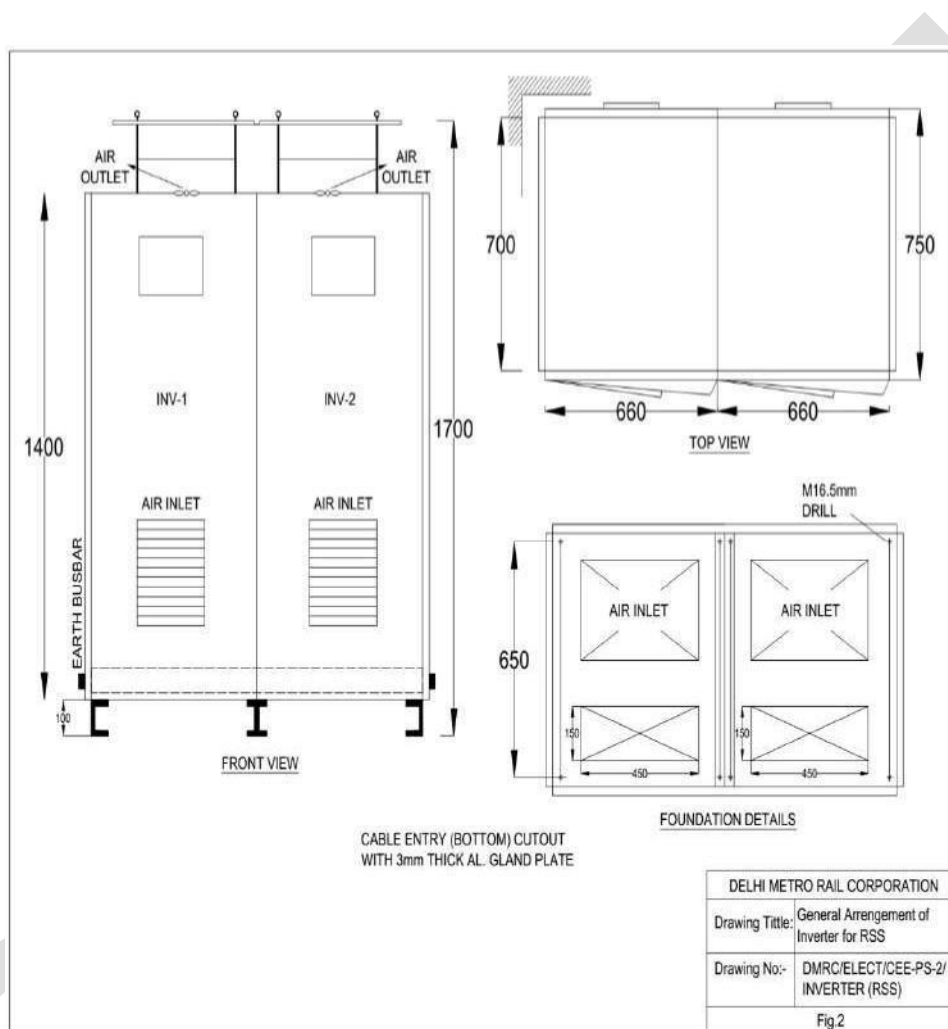
7. Test Sheet

All type tests and routine tests as per relevant IEC standards specified in technical specifications shall be carried out. For type tests, type test reports of not more than 5 years may be submitted.

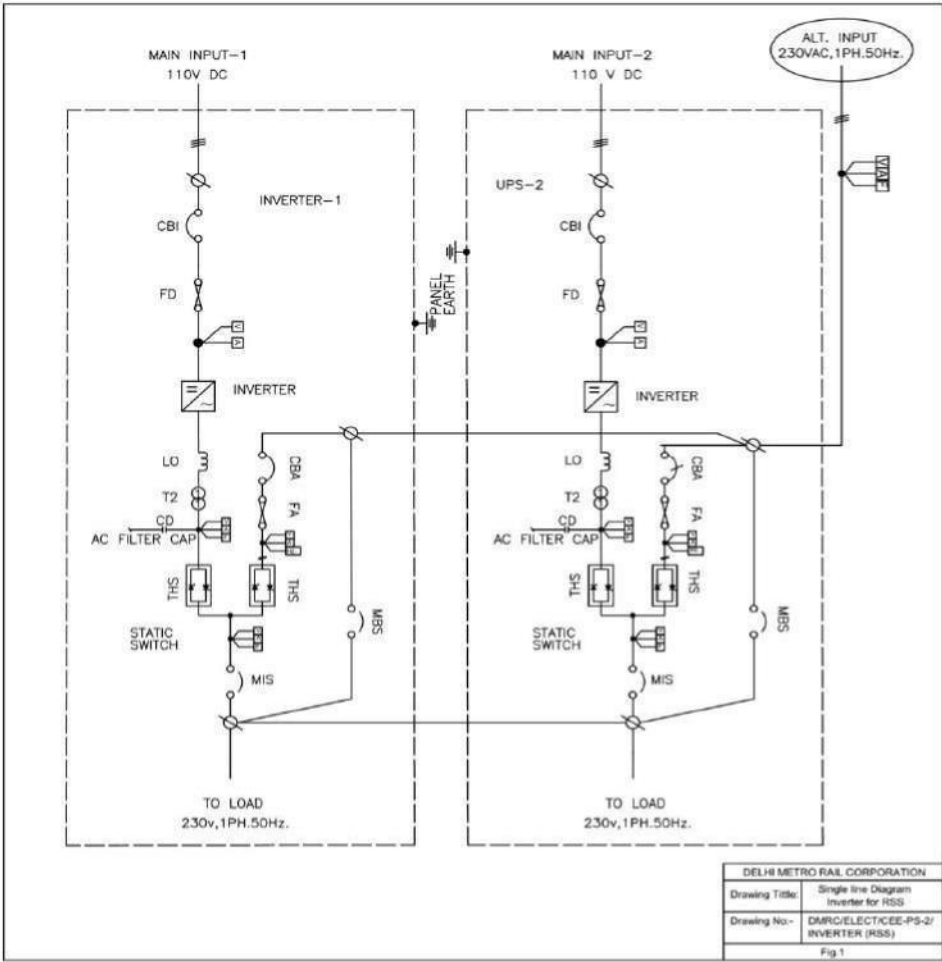
S. No	TYPE TEST Description	Remarks
1	Cable and Interconnection Check	All the Type Tests to be conducted either at manufacturer's laboratory or at any third party laboratory (NABEL accredited). In case tests are conducted at manufacturer's laboratory, third party (NABEL accredited) witness shall be arranged for.
2	Control Devices	
3	Protective Devices	
4	Auxiliary Devices	
5	Supervisory, Monitoring, Signaling Devices	
6	Auto transfer to bypass / isolation mode & back to normal	
7	Manual transfer to bypass / isolation mode and back to normal	
8	No Load	
9	Full Load	
10	Frequency Slew Rate	
11	Parallel redundant Inverter fail	
12	Transfer test to bypass	
13	Steady state input voltage tolerance	

14	Input frequency tolerance	
15	Input inrush current	
16	Harmonic distortion of input current	
17	Power factor	
18	Efficiency	
19	Standby generator compatibility	
20	Normal Mode - No Load	
21	Normal Mode - Full Load	
22	DC voltage component	
23	Current division across paralleled Inverter	
24	Output Overvoltage Test	
25	Periodic output voltage variation test (modulation)	
26	Overload - Normal Mode	
27	Overload - Stored Energy Mode	
28	Fault clearing capability - Normal Mode	
29	Fault clearing capability- Stored Energy Mode	
30	Dynamic Performance - Normal to Bypass Mode - Overload	
31	Dynamic Performance - Step Load to Normal Mode	

32	Dynamic Performance - Step Load to Stored Energy Mode	
33	Normal Mode - Full Load	
34	Stored Energy Mode - Full Load	
35	Dynamic Performance - Step Load to Normal Mode	
36	Dynamic Performance - Step Load to Stored Energy Mode	
37	Battery Ripple Current	
38	Restart Test	
39	Repetitive shock during transportation	
40	Free-fall during transportation	
41	Storage in dry heat, damp heat and cold environments	
42	Operation in dry heat, damp heat and cold environments	
43	Acoustic Noise	
44	Safety	
45	Electromagnetic Compatibility	

8. DRAWINGS OF INVERTER**a) General Arrangement of Inverter**

b) Single Line Diagram of Inverter



ANNEXURE-A5**CLEAN AGENT GAS BASED HIGH TEMPERATURE POLYMER TUBE
BASED PROTECTION SYSTEM****1. SCOPE: -1.1****General**

- (i) The scope covers Design, Supply, Installation, Testing and Commissioning of Automatic clean agent based Flooding System complete for Electrical Panels & Dry Type Station Transformer encloser complete with storage cylinder, indirect valves, flexible fire detection tubing as per NFPA-2001 including its safety guidelines with respect to "Hazard to Personnel" electrical clearance and environmental factors, integration with Main Fire Alarm Control Panel for status monitoring etc. The scope of work includes, but not limited to the following

- . Providing Direct Gas Flooding System with flexible fire detection/ discharge tubing inside the panels & transformer encloser.
- . Clean agent storage cylinder for flooding gas.
- . Fire Detection Tubing and spray nozzles
- . Manual discharge facility.
- . Interface with Fire Alarm System.
- . Audio-visual annunciation devices for indicating incidence of fire.
- . Any other item required to the successful commissioning of the system.

- (ii) The electrical panel & dry type station transformer encloser fire suppression system shall be complete with Direct Clean Gas storage cylinders for required capacities, extinguishing agent as specified, fire detection tubing, filling and end-of-line adaptors, pressure switches, control equipment, Clean Agent Cylinder/Valve Assembly, Cylinder Mounting Bracket and all necessary accessories to protect the Electrical panel & Transformer in case of fire. The system will have an interface with Main Fire Alarm and Control Panel. In case of fire in the concerned Panel/Transformer encloser, indication of Fire / Discharge

status should come in Main Fire Alarm and Control Panel. System Provider/Vendor has to submit authorization for use of clean agent/gas from the manufacturer.

- (iii) M/s OEM shall be involved in designing, planning, installation & commissioning of system and certify the system before taking over by the Employer. The PST contractor shall obtain vendor approval / Sub-PST contractor approval for the OEM & ITC PST contractor .
- (iv) The vendor shall submit recommended maintenance for the system including maintenance of sub components for approval of Employer's engineer..
- (v) The vendor shall organize Training for BSTP Staff for better familiarization of the system, installation Procedures & maintenance practices.

1.2 Design Requirements

- (i) All the detecting devices, alarm, indicating devices, containers and other related equipment shall have required approvals & authorization.
- (ii) Entire system, including all accessories etc. shall be of same make
- (iii) Complete installations shall conform to NFPA requirements.
- (iv) Clean Agent should be used with below mentioned properties
 - a) The Clean Agent should have Zero Ozone Depletion Potential. (ODP = 0)
 - b) The Clean Agent should not have Global Warming Potential of more than 1.
 - c) The Clean Agent should be a low pressure agent. **1.3**

System Equipment

① Tubing

The tubing shall be installed throughout the Electrical Panel & Transformer encloser with one end connected to the top of the Clean Agent container valve. The tubing shall be pressurized with Dry Nitrogen to 150 psig and maintains the system in the "OFF" position. The tube shall burst at temp. 100-120 degree Celcius. The tubing shall perform three functions viz. Heat Detection, System Activation and Clean Agent discharge. Tubing should be UL Listed.

② Clean agent Container

- > Design, fabricate, certify and stamp containers in accordance with the requirements of NFPA (DOT). Containers shall be standard model and size of ease of replacement and addition.
- > Each storage container shall be equipped with a nickel-plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the detection tubing. The quarter-turn ball valve shall be kept closed at all times when the container is not in service.
- > All container valves shall be equipped with a pressure relief valve (rupture disc) device in compliance with DOT requirements.

1.4 Technical and Installation Requirements

- (i) The system shall be a clean agent pre-engineered automatic indirect Fire Suppression System and shall be UL/FM Approved products and approval by Local Fire Authority.
The installation and commissioning of the system should be by Manufacturer or their authorised channel partner. The final connections between equipment and system detection tubing should be under direct supervision of factory trained and certified representative of manufacturer.
- (ii) Provide sufficient amount of Extinguishing Agent to Inert the Micro environment being protected considering the following when computing volume to verify suitability and to establish design limitations:
 - > Volume of hazard area.
 - > Specific volume of Clean Agent.
 - > Discharge time and flow rates.
 - > Design concentration and design factors.
 - > Detector/discharge tubing placement.
- (iii) The system shall be self-contained and have its own non-electric automatic detection system, which when actuated shall automatically release the suppression agent into the electrical panel/transformer cabinet.
- (iv) The system shall be complete in all respects. It shall include agent storage container, detection tubing, discharge nozzles, fittings manual release, abort stations, audible and visual alarm devices, and any other operations necessary for a functional Clean Agent suppression system.

- (v) The System shall detect, control and extinguish the fire and also simultaneously give audio visual indication on the control panel.
- (vi) Interface system with main control fire alarm system
- (vii) Storage containers shall be carefully located so that they are not subjected to mechanical, chemical or other damage.
- (viii) All doors and holes in the encloser/equipment should be closed or sealed to maintain the tightness of enclosure.
- (ix) The clean agent based Pre-Engineered automatic direct fire suppression system shall be with required approvals & Authorization.
- (x) Each clean agent pre-engineered automatic system is equipped with its own detection/discharge tubing. Vendor to submit detailed drawings & calculations based on NFPA & Specifications for Approval.
- (xi) The Clean Agent is stored in DOT steel cylinders as a liquefied compressed gas, super-pressurized with Dry Nitrogen to 150 psig at 70°F. The ambient operating temperature range for all system components should be 0 degree Celcius to 54 degree Celcius.
- (xii) Each container is equipped with a nickel-plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the Detection Tubing. In addition, the container valve shall be equipped with a pressure relief (rupture disc) device in compliance with DOT requirements.
- (xiii) Provide wall-mounted painted steel bracket to mount the container/valve assembly in a vertical (upright) position. Each bracket should be equipped with at least two integral quick-clamp straps as per manufacturer standard practice.
- (xiv) Install equipment as indicated on the approved shop drawings, and in accordance with requirements of NFPA-70 and NFPA-2001.
- (xv) All the necessary accessories required for operation of system shall be part of supply from single Manufacturer and the complete system shall have proven track record and International Third Party Approvals like UL, FM or any other reputed certification.
- (xvi) It shall be so designed that it does not affect the IP ratings of electrical panels/transformer

encloser. The Sub-PST contractor has to coordinate with manufacturer of electrical panels and station transformer for provision of holes to run the tube and brackets for mounting the tube. The entry of tube inside the panel/encloser shall be through suitable size of connector.

- (xvii) The tubing shall be manufactured from specially processed polymer material to achieve the desired heat detection and delivery characteristics. Provide minimum two runs of fire trace tube along with any two sides of every compartment of the panel/encloser.
- (xviii) The tubing shall be capable of working even when contaminated with oil, dust and debris as long as the contamination will allow the heat to pass through the tube.
- (xix) Distribution of Detection Tubing shall be ensured in each compartment of the Panel/encloser viz. Busbar Section, Switchgear Section and Cable Alleys etc. with routing on any two sides. Mounting/ installation of the detection tube to be as per manufacturer design.

1.5 System Operation

- (i) The system must operate automatically and its operation shall be as per following sequence: When the temperature of detection tube installed inside the Cabinet will increase to above 100 degree Celcius or the detection tube comes in the direct contact of flame, the tube shall burst and initiates ILP Valve which allows the diffusion of extinguishing medium which is Clean Agent gas through strategically placed pipes & nozzles.
- (ii) The system shall be designed for In Direct discharge of extinguishing agent through the pipes and nozzle when the tube rupture occurs. The diameter of tube for indirect discharge shall be as per calculations and manufacturer recommendations but shall not be less than 6mm under any condition.
- (iii) The PST contractor shall carry out the calculation and appropriate fill density to be arrived at basis of the same. Vendor to submit detailed drawings & calculations based on NFPA & Specifications for Approval.
- (iv) The design & calculation shall be checked & certified by manufacturers trained design engineer. The calculation is the only guarantee that the system shall work, provided the system is installed exactly as per the design.
- (v) These documents shall be prepared by a fully experienced person and qualified in the design of gas based fire suppression system.

1.6 Equipment Specifications**(i) Cylinder**

Design, fabricate, certify and stamp containers in accordance with the requirements of NFPA (DOT). Containers shall be standard model and size of ease of replacement and addition.

(ii) Discharge Hose

The Discharge Pipe should be high pressure braided hose with heavy duty adopters. The nozzle should be made of Brass/Gun Metal and should have 180 degree discharge pattern.

(iii) System and Detection Tube

a) The System will be UL/FM approved product

b) Clean Agent should be used with below mentioned properties:

- . The Clean Agent should have Zero Ozone Depletion Potential. (ODP = 0)
- . The Clean Agent should not have Global Warming Potential of more than 1.
- . The Clean Agent should be a low pressure agent.

The detection tube shall be manufactured from specially processed polymer material to achieve the desired heat detection and delivery characteristics. The tube shall be capable of working even when contaminated with oil, dust and debris as long as the contamination will allow the heat to pass through the tube.

DETAILS of PANELS IN WHICH SUPPRESSION SYSTEM IS TO BE PROVIDED:

The following is an indicative list of Panels for providing Fire suppression system -

S. No.	Equipment details
1.	33KV MV Panel
2.	25 kV panel (if any)
3.	ACDB
4.	DCDB
5.	Battery Charger
6.	Dry type Transformer
7.	Inverter/UPS

(iv) Control Box

- > Every unit of Panel/Transformer flooding system has to be provided with a Control Box for giving Audio/Visual Alarm and interface with panel/Transformer flooding system for accepting gas release signal and further relay of the same to Fire Alarm Control Panel (FACP).
- > The control box enclosure shall be at least IP 54. Wiring of the Control Box shall be FS type as per BS 6387/ FRPVC as per IS 694 and shall be minimum 2.5 sqmm. The control box shall be fire red in colour having 2mm thick CRCA sheet with powder coated finish.
- > The unit shall contain indication for System Healthy, Mains Healthy and Gas Release. The unit shall also have signal silence button. All components such as Hooter, Strobe, Indication Lamps, Chip shall be of superior make subject to approval by Engineer.
- > Third party test reports for IP and Functionality of the system to be submitted before approval. The system shall be supplied and certified by OEM of the flooding system or their authorized vendor.

ANNEXURE-A6**FIRE ALARM AND DETECTION SYSTEM****1. General**

This Section specifies the scope of work, design, supply, installation, testing & commissioning of the Fire Alarm and Detection System.

The system shall be an intelligent addressable fire alarm and detection system. For RSS, NBC & IS 2189 shall be used as guiding standard and design of the Fire alarm System.

2. Scope of Work

The scope of the work is to design, supply, installation, testing and commissioning of intelligent addressable fire alarm and detection system in compliance with codes and standard mentioned in this specification, Outline design Criteria and International best practices for all RSS etc. The Addressable Fire alarm system will comprise of the following:

- > Micro-processor based Main Fire Alarm Panel
- > Addressable Multi-sensor Detector, smoke detectors, heat detectors, Beam detector etc.
- > Addressable manual call points
- > Addressable Hooter cum strobe (either addressable or made addressable through control module)
- > Batteries and charger
- > Electrical wiring, conduits, and accessories
- > Communication driver at the FACP for interfacing with the SAS
 - > Voltage free fire alarm signals through voltage free normally close contacts from the fire alarm system to the SAS and connecting cables between the fire alarm system and SAS for all interfaces.

The Addressable Main Alarm Panel will be minimum 2 loops for RSS with a Loop capacity of minimum 150 devices/detectors as per manufacturer design and UL listing. The panel will be located in the Control Room and will have LED alpha-numeric display.

The fire alarm panel will have the capability to process and evaluate incoming signals from addressable devices such as smoke detectors, heat detectors, duct detector, combined optical and heat detectors, beam detectors, manual call point and I/O modules etc. via FRPVC insulated copper wires as per IS 694 in GI conduits or FRLSH PVC insulated copper conductor cables as per IS1554 for elevated stations ,Depots and RSS. Fault isolators will be provided after every 20 devices.

The Fire Alarm System will be provided with input modules for interface with flow switches and relay module for interface with the SAS system and Output Module to Hooter cum strobe. Fire Alarm System shall be capable of integration with:

- > To be seamlessly interfaced with SCADA system
- > Audio and strobes signal to areas in the RSS building in case of alarm

3. Technical and Installation Requirements

3.2 Quality Control

3.2.1 Provide equipment which are products of manufacturers who have made these products for a period of at least ten years, Complete System shall be the latest developed products which have been listed by UL.

3.2.2 The system components such as control panel, detectors, line break isolator, response indicators, repeater panel, Mimic panel, modules, battery, Two-way Talkback System (Only for Depots) and all fire alarm devices shall be of the same manufacturer and under one family design duly approved/listed by UL. All Fixing accessories like back-boxes etc. shall either be the same manufacturer or of superior quality duly certified by OEM and approved by Engineer.

3.3 Control Panel

3.5.2 The fire alarm control panel (FACP) shall be multi-zone control panel of the intelligent analogue addressable type, complete with power supply, battery charger, batteries.

3.5.3 The Fire Alarm Control Panel shall be located within the Control Room, capable of interface with a Workstation for the Fire Detection & Suppression system. All the fire detectors, alarm devices and interfaces to other systems shall be connected via this panel.

3.5.4 The FACP shall be analogue addressable in a lockable housing with illuminated function keys

and capable of full "stand-alone" operation. The FACP housing shall be to a minimum protection rating of IP 54.

3.5.5 The FACP shall be minimum 2 Loop for RSS control panel with loops expandable feature and of intelligent addressable type with a loop capacity of minimum 150 devices/ detectors as per manufacturer's design and UL listing complete with all alarm loop cards and input / output control interface, at least 120 LED character display or greater, easily operable with acknowledgement, reset and silence facility.

3.5.6 Activation of Manual call points or detectors shall be identified on the FACP identifying the loop number and detector address number including the associated Fire Alarm zone. This information shall be provided via a textual message on a separate screen integral to the FACP. Fire alarm panels shall be lockable with alarm/reset functions; On/Off controls and alarm disable controls. A facility shall be provided to allow operating access to authorized personnel. This shall be via key or password access.

3.5.7 The FACP shall be self-checking and shall have the facility to identify faulty/ contaminated devices or system malfunctions such that faulty status/condition shall not be confused with fire alarms.

3.5.8 The processor shall be capable of polling all field devices on a loop within three seconds.

3.5.9 A facility shall be provided to isolate a single device on a loop or a group of devices on a loop on a temporary basis. An illuminated warning indication shall be provided on the FACP, which shall remain lit until the isolation is removed.

3.5.10 The FACP shall have an integral clock, which shall be synchronized with the Station centralized clock system (provided by others). A facility shall be provided to allow for an external logging printer to be connected. The printer shall be located within the Control Room. The station FACP shall be equipped with monitoring/relay points to relay status and alarm messages to the SCADA system.

3.5.11 Relays points shall be provided for:

- a) FAP healthy signal,
- b) Fire alarm condition,
- c) Fire zone of such alarm condition,

3.5.12 FACP shall be capable of interfacing with other systems including but not limited to:

a) Clean Agent Based Panel & Transformer Flooding System: The FACP shall receive signals from the individual Gas suppression system control panels to identify activation of clean agent based panel/transformer flooding system.

b) FACP shall also interface with SCADA system and all other systems as per

3.5.13 The response to alarms from various combinations of the detectors, manual call points shall, via the dedicated microprocessor, shall be capable of initiating performance of such other functions as required like:

a) Alert RSS staff,

b) Initiate operation of Fire Suppression Equipment,

c) Capable to initiate signal for operating any other emergency devices as per requirement.

3.5.14 All detector and bell circuits shall be continuously monitored and a fault on any of these shall be indicated in the Main Fire Alarm Panel.

3.5.15 FACP shall be capable of control and monitoring of Gas suppression system. **3.5.16** Each system shall provide at least 25 % spare capacity for future expansion.

3.5.17 Access rights for Fire Alarm Control Panel with all necessary Hardware & Software to be provided to BSTP for any change, addition/deletion or modification in the system. The access shall be unconditional and manufacturer to provide necessary support to BSTP including training to BSTP personnel for the same. Any hardware required for software access shall be a part of the system without any cost implication and without any requirement for periodic renewal. The manufacturer is required to provide all software upgradations free of cost to BSTP during the entire life of the product.

The installation and commissioning of the FACP shall be done by manufacturer or their approved channel partner. The manufacturer will also be required to ensure overall supervision of the fire detection cabling and detector/ device fixing works.

3.4 Battery Charger and Batteries

A 24 V DC trickle type battery charger and batteries shall be provided. The unit shall

incorporate Trickle charger assembly, Rotary type selector switch, Suitably rated fuse, Sealed Maintenance Free battery as per UL listing, Rectifiers and DC output voltage stabilizer as required.

The unit shall be suitable for use on a 240 V AC single phase power supply and shall automatically maintain the 24 V DC batteries in a state approximate to full charge and at the same time to compensate for the standing load. The charger shall cater for re-charging the battery from fully-discharged condition to fully-charged condition in not more than 24 hours.

Battery shall be of sealed maintenance free battery as per UL Listing requiring no maintenance throughout the normal life of the battery and shall be of capacity capable of maintaining the system in normal working condition for at least 48 hours without recharging and subsequently operating in the "alarm" condition continuously for at least one hour.

3.5 Break-glass Units / Manual Call Point

3.5.1 Manual call point shall comply with NFPA/NBC(IS) and shall be UL approved/listed. They shall be addressable type and shall be arranged to operate automatically upon pressing call point switch. The cover shall be locked in position with a special key and the glass panel shall be clipped firmly into place. It shall be manufactured in bright red compliant material, measuring 85 x 85 mm with 50mm overall depth or as approved/required by engineer. Operation shall be via a plastic membrane (non-breakable) with wording on method of operation in white lettering. The cover shall be etched in black lettering in Hindi and English "FIRE", the letters measuring not less than 10mm high.

3.5.2 The surface of the Manual call point shall be provided with a LED indicator. It shall light up upon activation of the Manual call point. The operation of any call point connected to the system shall cause the RSS FACP to enter the alarm state within three seconds.

3.5.3 Contacts shall be of silver or approved non-deteriorating alloy, for normally close/open system. The voltage and current ratings of the contacts shall be marked within the unit.

3.5.4 The units shall be of the flush mounting type and suitable for direct connection to the type of wiring system therein specified without the addition of unsightly surface boxes, glands and adaptors. Special boxes compatible with the conduit system shall be provided where necessary for installation of the call points.

3.5.5 Manual call point shall be positioned at a height of 1.2 m or as per NFPA/NBC (IS) at strategic

points throughout the station such that they are clearly visible from front and sides as practicable and Manual call point shall be located at every entrance and at such locations so that one is within 22.5 meters of any point in the RSS or as per NFPA/NBC (IS) have to be provided. Provide flush plates for the recess mounting units.

3.5.6 The alarm bells and flashing light units shall actuate upon receipt of a fire alarm signal from any of the Manual call points or detection systems.

3.5.7 Each Manual call point shall be complete with built-in testing slot, such that testing can be carried out by insertion of the test key without removing the glass front cover of the unit

3.6 Detectors with associated base 3.6.2

General

- a) Unless otherwise specified, smoke detectors shall be of multi sensor type.
- b) Detectors shall be UL listed, multi-sensor. The internal circuits shall be of solid state device and shall be hermetically sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock. All circuitry shall be protected against typical electrical transients and electromagnetic interference.
- c) Each detector shall carry a built-in address.
- d) There shall be a built-in magnetic test/any other mock test facility in each intelligent device.
- e) Built-in testing facility shall be provided based on NFPA 72.
- f) The detector base shall have a positive mechanical means to hold the removable portion of the device. However, such provision shall provide a simple means to remove the detector from the base, either by hand or by the use of a special tool that can plug-in and/or remove the detector head from a distance of up to 6 m above floor level.
Required tool to be provided by vendor
- g) Detector base shall be compatible for connection of all types of analogue addressable detectors and shall have the facility to drive a remote visual alarm indicator which shall be provided for all concealed detectors. Remote indicator shall be compatible with the detector so that the operation of the indicator will not impair or affect the brightness of the detector's built-in LED.

- h) There shall be LEDs on the detector head so that alarm condition of the detector can be seen clearly from any direction or angle.
- i) The designed operating range of detectors shall be between 0 °C and 50 °C and up to 95% RH non-condensing or as per NFPA/NBC (IS).
- j) There shall be at least 3 levels (high, medium and low) of sensitivity, as approved by the agency listed or by Bangalore Fire and Emergency Services, which can be selected at any time at the FS control panel or by automatic day/night sensitivity change over program which shall be built into the FS control panel.
- k) Detector shall be low profile, no more than 60mm in height or as approved by Engineer including the base to minimize dust accumulation at detector head, resulting from the pattern of airflow.
- l) The remote indicator with labelling shall be provided for all detectors installed above false ceiling as specified in clause (g) of this Specification.
- m) Labels shall be provided adjacent to all detectors with appropriate letters indicating the corresponding address.

3.6.3 Multi-Sensor Detectors

- a) The multi sensor detector shall be a microprocessor based and operate on light scattering principle, containing an emitter and photo sensor. The scattered light reaching the photo sensor shall be proportional to the smoke density inside the detection chamber. It will combine both optical smoke and heat detector technology to detect clear burning fire products, which hitherto could only be easily detected by ion-chamber detectors. The detectors will not operate on a rate of rise of temperature alone. It shall be UL listed.
- b) The detector shall utilize advanced algorithms with time based analysis to provide early warning and an accurate analysis of alarm situations.
- c) Under normal ambient conditions, the optical detector will behave as a normal optical detector. Only when a rapid rise in temperature is detected, the sensitivity of the detector shall increase together with the presence of smoke shall confirm a fire condition, which will be transmitted as a fire alarm level.
- d) The detector will be fully compensated for temperature, humidity and barometric

changes in the environment. All electronic components shall be hermetically sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock. All circuitry must be protected against typical electrical transients and electromagnetic interference. The detector will be fully operable between -20 °C and + 70 °C and up to 95% relative humidity non-condensing or as specified by NFPA/NBC(IS).

- e) The Sensitivity shall be adjustable by means of a pre-set control only accessible by use of a special tool. Built-in wind-shields will be provided to ensure that air velocity of up to 10 meters / second do not affect the proper operation of the detector.

3.6.4 Heat Detectors

- a) Heat detector shall be an analogue addressable type designed to raise an alarm when the temperature is at a rate-of-rise of 8 °C per minute or higher or at a fixed alarm temperature of 57 °C. It shall be UL listed and Bangalore Fire and Emergency Services approved.
- b) The detector shall employ two matching thermal sensing elements in a bridge configuration to give a response, which depends both on absolute temperature and rate of change of temperature. The reference and sensing thermal sensors shall be fabricated under identical conditions to ensure good matching and tracking with both temperature and ageing.

3.6.5 Beam Detectors

- a) Beam detectors shall generate an alarm if smoke affects the Infra Red Beam between transmitter and a receiver unit.
- b) Specification for beam detector:
 - ☐ Monitoring Length – 5 Mtrs. to 100 Mtrs.
 - ☐ Signal Processing – 8 Bit Microprocessor
 - ☐ Sensitivity – 3 steps adjustable (25, 50, 70%)
 - ☐ Compensation – Pollution of the optics is hourly compensated to + 1%

3.6.6 Hooter cum Strobe (either addressable or made addressable through control module)

All the areas of RSS shall be provided with sounder cum visual strobe units.

The unit shall be wall mounted, approved color, suitable for operation on 24V with following features.

- a) Visual Characteristics: The visual strobe shall consist of Xenon flash tube with associated lens / reflector. The feature selectable candela outputs (15, 15/75, 30, 75 or 110). The flash rate shall not exceed two flashes per second (2Hz) and nor less than one flash per second (1 Hz) throughout the listed operating range of appliances or as per NFPA/NBC (IS) and UL.
- b) The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90° degree angle on both sides of the strobe.
- c) Sounder pulse rate and decibel level above the ambient shall comply with NFPA/NBC (IS) standards. The unit shall be tapped for 1/4, 1, 2 and 4 watts outputs.
- d) Strobe shall be placed wall mounted in corridors no more than 4570 mm (15 feet) from the end of a corridor with 30.48 m (100 feet) maximum distance between strobes or as per NFPA/NBC(IS). Where there is an obstruction to the viewing path in the corridors, such as a cross-corridor door or ceiling elevation change, consider the obstruction as defining a new corridor.

3.6.7 Fire Alarm Cables

RSS cabling to be FR PVC insulated wire as per IS 694 in GI Conduits or FRLSH PVC insulated cable as per IS 1554 with copper conductors of cross section 1.5 sq. mm. or above as per BOQ

3.6.8 Monitor Modules

Addressable contact monitoring module shall communicate via the detection cable loop with the Fire Alarm Control Panel for continuous monitoring of any NO or NC dry contacts connected including break glass, flow switch and repeating dry contact signals from gas flooding system and gas detection system. LED indication shall be provided to show the status of the module.

3.6.9 Control Modules

- a) Control module shall provide an addressable output for a separately powered alarm indicating circuit or for a control relay and housed in covered galvanized steel or stove enamel steel box with sufficient size to house all modules.
- b) The control module shall provide a supervised indicating circuit where indicated on the Drawings. Any open/short circuit fault shall be detected/highlighted/displayed at the Fire Alarm Control Panel. Subsequent fire alarm signals shall activate the appropriate controls and signaling devices despite of the fault conditions.
- c) The control module shall act as a control relay where required.
- d) The control module shall contain a LED which blinks upon being scanned by the Fire Alarm Control Panel. Upon activation of the module, the LED shall be latched on.
- e) Status of control module shall be fed back to Fire Alarm Control Panel and print out automatically once it is activated.

3.6.10 Fault Isolator Modules

- a) Fault isolator modules shall detect and isolate a short-circuited segment of a fault-tolerant loop.
- b) The module shall automatically detect a return-to-normal condition of the loop and restore the isolated segment.
- c) Modules shall be provided for every 20 field addressable devices to limit the extent of devices affected in the event of short-circuit. A minimum of two fault isolator modules shall be provided for one detection line loop.
- d) The repeater panel enclosure shall be flush mounted and all electronics shall be contained in the enclosure. Access to the repeater panel switches shall be protected by key-switch.
- e) The panel construction shall be as per Specification. One repeater panel has to be provided at each fireman's staircase.

3.6.11 Response Indicator

- a) Response indicator of LED type shall be provided for above false ceiling and below false floor

detectors and these shall be mounted outside/ inside the rooms wherever asked for by the PST contractor /Employer representative for indication of fire through detector in the room.

The design & colour shall be as per the standard.

- b) In RSS, for areas with room height more than 5m, UL listed beam detector to be provided and integrated with the main fire alarm system of RSS.

ANNEXURE-A7

The typical requirement for the various equipment's input and output signal list have been indicated below:

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
1.	33kV Auxiliary Transformer feeder	Local/Remote Indication	SPI	√				√	
2.		Permission for Local Control	DPI	√			√		
3.		110V DC Control Voltage Fail	SPI	√			√		
4.		CB Status (Close/Open) Indication	DPI	√				√	
5.		CB in Test Position	SPI	√				√	
6.		CB in Service Position	SPI	√				√	
7.		CB Trip Circuit Unhealthy	SPI	√				√	
8.		IED Relay Faulty	SPI	√			√		
9.		Relay comm fail	SPI	√				√	
10.		Spring Discharged	SPI	√				√	
11.		BOES-01 Earth Switch Status (Close/Open) Indication	DPI	√				√	
12.		CB (Open/Close) Command	DCO		√			√	
13.		SCADA Permissive for Local Control	DCO		√		√		
14.		Master trip relay reset command	SCO		√			√	
15.		IED 1 Protection Signal							
16.		Low Set Over Current Protection (Alarm)	SPI	√				√	
17.		Low Set Over Current Protection (Trip)	SPI	√				√	
18.		High Set Over Current Protection (Alarm)	SPI	√				√	
19.		High Set Over Current Protection (Trip)	SPI	√				√	
20.		Low Set Earth Fault Protection (Alarm)	SPI	√				√	
21.		Low Set Earth Fault Protection (Trip)	SPI	√				√	
22.		High Set Earth Fault Protection (Alarm)	SPI	√				√	
23.		High Set Earth Fault Protection (Trip)	SPI	√				√	
24.		Stand By Earth Fault Protection (Alarm)	SPI	√				√	
25.		Stand By Earth Fault	SPI	√				√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
		Protection (Trip)							
26		Master trip relay operated	SPI	√				√	
27		PT Secondary MCB ON	SPI	√				√	
28		Winding Temp. High Alarm	SPI	√				√	
29		Winding Temp. High Trip	SPI	√				√	
30		Transformer Door open	SPI	√				√	
31		Measurement Signal							
32		R-Y phase Voltage	MVI			√		√	
33		Y-B phase Voltage	MVI			√		√	
34		B-R phase Voltage	MVI			√		√	
35		R phase current	MVI			√		√	
36		Y phase current	MVI			√		√	
37		B phase current	MVI			√		√	
38		Frequency	MVI			√		√	
39		PF Average	MVI			√		√	
40		R-N Voltage	MVI			√		√	
41		Y-N Voltage	MVI			√		√	
42		B-N Voltage	MVI			√		√	
43		VA Total	MVI			√		√	
44		VAR Total	MVI			√		√	
45		Watts Total	MVI			√		√	
46		WH Received	MVI			√		√	
47		WH Delivered	MVI			√		√	
48		VARH Received	MVI			√		√	
49		VARH Delivered	MVI			√		√	
1.	33kV Outgoing feeder	Local/Remote Indication	SPI	√				√	
2.		Permission for Local Control	DPI	√			√	√	
3.		IED 1 Faulty	SPI	√			√		
4.		IED 2 Faulty	SPI	√			√		
5.		Relay comm-1 fail	SPI	√				√	
6.		Relay comm-2 fail	SPI	√				√	
7.		110V DC Control Voltage Fail	SPI	√			√		
8.		CB Status (Close/Open) Indication	DPI	√				√	
9.		CB in Test Position	SPI	√				√	
10.		CB in Service Position	SPI	√				√	
11.		CB Trip Circuit Unhealthy	SPI	√				√	
12.		Spring Discharged	SPI	√				√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
13		BOES-3 Earth Switch Status (Close/Open) Indication	DPI	√				√	
14		CB (Open/Close) Command	DCO		√			√	
15		SCADA Permissive for Local Control	DCO		√		√		
16		Master trip relay reset command	SCO		√			√	
17		IED 1 Protection Signal							
18		Low Set NDR Over Current Protection (Alarm)	SPI	√				√	
19		Low Set NDR Over Current Protection (Trip)	SPI	√				√	
20		High Set NDR Over Current Protection (Alarm)	SPI	√				√	
21		High Set NDR Over Current Protection (Trip)	SPI	√				√	
22		Low Set NDR Earth Fault Protection (Alarm)	SPI	√				√	
23		Low Set NDR Earth Fault Protection (Trip)	SPI	√				√	
24		High Set NDR Earth Fault Protection (Alarm)	SPI	√				√	
25		High Set NDR Earth Fault Protection (Trip)	SPI	√				√	
26		UV Alarm	SPI	√				√	
27		UV Trip	SPI	√				√	
28		Master trip relay operated	SPI	√				√	
29		R phase IED current	IED MFI			√		√	
30		Y phase IED current	IED MFI			√		√	
31		B phase IED current	IED MFI			√		√	
32		V R-Y phase	IED MFI			√		√	
33		V Y-B phase	IED MFI			√		√	
34		V B-R phase	IED MFI			√		√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
35		IED 2 Protection Signal							
36		Line differential Optd	SPI	√				√	
37		Line differential Alarm (Start)	SPI	√				√	
38		Line differential Communication Fail	SPI	√				√	
1.	Incoming feeder from power transformer	Local/Remote Indication	SPI	√				√	
2.		Permission for Local Control	DPI	√			√		
3.		110V DC Control Voltage Fail	SPI	√			√		
4.		CB Status (Close/Open) Indication	DPI	√				√	
5.		CB in Test Position	SPI	√				√	
6.		CB in Service Position	SPI	√				√	
7.		IED Relay Faulty	SPI	√			√		
8.		Relay comm fail	SPI	√				√	
9.		CB Trip Circuit Unhealthy	SPI	√				√	
10		Spring Discharged	SPI	√				√	
11		BIES-1 Earth Switch Status (Close/Open)Indication	DPI	√				√	
12		CB (Open/Close) Command	DCO		√			√	
13		SCADA Permissive for Local Control	DCO		√		√		
14		Master trip relay reset Command	SCO		√			√	
15		IED Protection Signal							
16		Low Set Over Current Protection (Alarm)	SPI	√				√	
17		Low Set Over Current Protection (Trip)	SPI	√				√	
18		High Set Over Current Protection (Alarm)	SPI	√				√	
19		High Set Over Current Protection (Trip)	SPI	√				√	
20		Low Set Earth Fault Protection (Alarm)	SPI	√				√	
21		Low Set Earth Fault Protection (Trip)	SPI	√				√	
22		High Set Earth Fault Protection (Alarm)	SPI	√				√	
23		High Set Earth Fault Protection (Trip)	SPI	√				√	
24		UV Alarm	SPI	√				√	
25		Trip from UP Steam	SPI	√				√	
26		Master trip relay operated		√					

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
			SPI					√	
27		PT Secondary MCB ON	SPI	√				√	
28		R phase IED current	IED MFI			√		√	
29		Y phase IED current	IED MFI			√		√	
30		B phase IED current	IED MFI			√		√	
31		V R-Y phase	IED MFI			√		√	
32		V Y-B phase	IED MFI			√		√	
33		V B-R phase	IED MFI			√		√	
34		MFM Signal							
35		R-Y phase Voltage	MVI			√		√	
36		Y-B phase Voltage	MVI			√		√	
37		B-R phase Voltage	MVI			√		√	
38		R phase current	MVI			√		√	
39		Y phase current	MVI			√		√	
40		B phase current	MVI			√		√	
41		Frequency	MVI			√		√	
42		PF Average	MVI			√		√	
43		R-N Voltage	MVI			√		√	
44		Y-N Voltage	MVI			√		√	
45		B-N Voltage	MVI			√		√	
46		VA Total	MVI			√		√	
47		VAR Total	MVI			√		√	
48		Watts Total	MVI			√		√	
49		WH Received	MVI			√		√	
50		WH Delivered	MVI			√		√	
51		VARH Received	MVI			√		√	
52		VARH Delivered	MVI			√		√	
1.	BCCB	Local/Remote Indication	SPI	√				√	
2.		Permission for Local Control	DPI	√			√		
3.		110V DC Control Voltage Fail	SPI	√			√		
4.		IED Faulty	SPI	√			√		
5.		Relay comm fail	SPI	√				√	
6.		CB Status (Close/Open) Indication	DPI	√				√	
7.		CB in Test Position	SPI	√				√	
8.		CB in Service Position	SPI	√				√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
9.		CB Trip Circuit Unhealthy	SPI	√				√	
10		Spring Discharged	SPI	√				√	
11		Local breaker back up (LBB) Operate	SPI	√				√	
12		BCES-1 Earth Switch Status-1 (Close/Open) Indication	DPI	√				√	
13		BCES-2 Earth Switch Status-2(Close/Open) Indication	DPI	√				√	
14		CB (Open/Close) Command	DCO		√			√	
15		SCADA Permissive for Local Control	DCO		√		√		
16		Master trip relay reset command	SCO		√			√	
17		IED 1 Protection Signal							
18		Low Set Over Current Protection (Alarm)	SPI	√				√	
19		Low Set Over Current Protection (Trip)	SPI	√				√	
20		High Set Over Current Protection (Alarm)	SPI	√				√	
21		High Set Over Current Protection (Trip)	SPI	√				√	
22		Low Set Earth Fault Protection (Alarm)	SPI	√				√	
23		Low Set Earth Fault Protection (Trip)	SPI	√				√	
24		High Set Earth Fault Protection (Alarm)	SPI	√				√	
25		High Set Earth Fault Protection (Trip)	SPI	√				√	
26		Stand by Earth Fault Protection (Alarm)	SPI	√				√	
27		Stand by Earth Fault Protection (Trip)	SPI	√				√	
28		Bus PT Supply BUS-1 Healthy	SPI	√				√	
29		Bus PT Supply BUS-2 Healthy	SPI	√				√	
30		Master trip relay operated	SPI	√				√	
31		PT Secondary MCB ON	SPI	√				√	
32		R phase IED current	IED MFI			√		√	
33		Y phase IED current	IED MFI			√		√	
34		B phase IED current	IED			√		√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
			MFI						
35		V R-Y phase	IED MFI			√		√	
36		V Y-B phase	IED MFI			√		√	
37		V B-R phase	IED MFI			√		√	
1.	Energy Meter	Voltage	MVI			√		√	
2.		current	MVI			√		√	
3.		Power factor	MVI			√		√	
4.		kW	MVI			√		√	
5.		KVAR	MVI			√		√	
6.		KVA	MVI			√		√	
7.		KWH	MVI			√		√	
8.		KVARH	MVI			√		√	
1.	Battery Charger - 1	KWAH	MVI			√		√	
2.		On Boost	SPI	√			√		
3.		I/P Fuse blown	SPI	√			√		
4.		O/P Fuse blown	SPI	√			√		
5.		Charger Main Unhealthy	SPI	√			√		
6.		Charger Fault	SPI	√			√		
7.		DC Under Voltage	SPI	√			√		
8.		DC Over Voltage	SPI	√			√		
9.		Earth Leakage	SPI	√			√		
10		Battery Low	SPI	√			√		
11		Common Fault	SPI	√			√		
12		AC main Fail	SPI	√			√		
13		Output Voltage	MV			√	√		
14		Output Current	MV			√	√		
1.	LVACB I/C-1,2 & LVACCB	Close/Open Position	DPI	√			√		
2.		Local/Remote Indication	SPI	√			√		
3.		SCADA Local Permissive Indication	DPI	√			√		
4.		Service Position	SPI	√			√		
5.		DC Fail	SPI	√			√		
6.		Under Voltage	DPI	√			√		
7.		Trip Signal	SPI	√			√		
8.		Spring Status	SPI	√			√		
9.		SCADA Local Permissive Command	DCO		√		√		
10		Close/Open Command	DCO		√		√		

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
1.	DCDB I/C-1,2 and DCDCB	Close/Open Position	DPI	√			√		
2.		Local/Remote Indication	SPI	√			√		
3.		SCADA Local Permissive Indication	DPI	√			√		
4.		Service Position	SPI	√			√		
5.		DC Fail	SPI	√			√		
6.		Earth Fault	SPI	√			√		
7.		Under Voltage	SPI	√			√		
8.		Trip Signal	SPI	√			√		
9.		Over Voltage	SPI	√			√		
10.		Close/Open Command	DCO		√		√		
11.		SCADA Local Permissive Command	DCO		√		√		
1.	220kV TRFO-1 & 2	AOCB1 Command	DCO		√			√	
2.		AOIS1 Command	DCO		√			√	
3.		QB Command	DCO		√			√	
4.		QC Command	DCO		√			√	
5.		Phy Health7	DPI	√				√	
6.		AOCB1 Position	DPI	√				√	
7.		AOIS1 Position	DPI	√				√	
8.		Phy Health1	DPI	√				√	
9.		QB Position	DPI	√				√	
10.		QC Position	DPI	√				√	
11.		OC Protection Operated	SPI	√				√	
12.		OC/EF B phase Trip	SPI	√				√	
13.		OC/EF R phase Trip	SPI	√				√	
14.		OC/EF Y phase Trip	SPI	√				√	
15.		OC Protection Start	SPI	√				√	
16.		86A Reset	SPI	√				√	
17.		86B Reset	SPI	√				√	
18.		Relay communication fail	SPI	√				√	
19.		B Phase Trip	SPI	√				√	
20.		BB Relay Reset	SPI	√				√	
21.		CB Spring Charged	SPI	√				√	
22.		CB TC1 Healthy	SPI	√				√	
23.		CB TC2 Healthy	SPI	√				√	
24.		CB SF6 Lockout	SPI	√				√	
25.		CB SF6 Repl Alarm	SPI	√				√	
26.		CB SCADA selected	SPI	√				√	
27.		CT SF6L Y Phase	SPI	√				√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
28		CT SF6A Y Phase	SPI	√				√	
29		CT SF6A B Phase	SPI	√				√	
30		CT SF6A R Phase	SPI	√				√	
31		CT SF6L B Phase	SPI	√				√	
32		CT SF6L R Phase	SPI	√				√	
33		Diff Protection Start	SPI	√				√	
34		DP Operated	SPI	√				√	
35		R Phase Trip	SPI	√				√	
36		REF Protection Alarm	SPI	√				√	
37		REF Protection trip	SPI	√				√	
38		Stand By EF Protection Trip	SPI	√				√	
39		Stand By EF Protection Start	SPI	√				√	
40		Tank EF Protection Trip	SPI	√				√	
41		Tank EF Protection Start	SPI	√				√	
42		Y Phase Trip	SPI	√				√	
43		HV WTI	SPI	√			√		
44		LV WTI	SPI	√			√		
45		OTI	SPI	√			√		
46		TAP POS	SPI	√			√		
47		CB Permissive command	DCO		√		√		
48		NGR Permissive command	DCO		√		√		
49		OG Dis Permissive command	DCO		√		√		
50		BUCHLZ Alarm	SPI	√			√		
51		BUCHLZ Trip	SPI	√			√		
52		CB Permissive Indication	SPI	√			√		
53		DC Fail Alarm	SPI	√			√		
54		Fan Mode	SPI	√			√		
55		MOLG Alarm Main Tank	SPI	√			√		
56		MOLG Alarm OLTC	SPI	√			√		
57		NGR Permissive	SPI	√			√		
58		OG Dis Permissive	SPI	√			√		
59		OSR TRIP	SPI	√			√		
60		OTI Alarm	SPI	√			√		
61		OTI TRIP	SPI	√			√		
62		PRV TRIP	SPI	√			√		
63		WTI Alarm	SPI	√			√		
64		WTI TRP HV	SPI	√			√		
65		WTI TRP LV	SPI	√			√		

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
66		NIFPS active alarm	SPI	√			√		
1.	132kV I/C-1 & 2	AICB1 Command	DCO		√			√	
2.		AISO1 Command	DCO		√			√	
3.		AISO3 Command	DCO		√			√	
4.		AICB1 Position	DPI	√				√	
5.		AISO1 Position	DPI	√				√	
6.		AISO3 Position	DPI	√				√	
7.		Relay comm-1 fail	SPI	√				√	
8.		Phy Health8	DPI	√				√	
9.		86A Reset	SPI	√				√	
10		86B Reset	SPI	√				√	
11		B Phase Trip	SPI	√				√	
12		BB Relay Reset	SPI	√				√	
13		Cable DP Start	SPI	√				√	
14		CB Spring charged	SPI	√				√	
15		CB TC1 Healthy	SPI	√				√	
16		CB TC2 Healthy	SPI	√				√	
17		Cable Differential Protection Operated	SPI	√				√	
18		CBSF6Lockout	SPI	√				√	
19		CBSF6ReplAlarm	SPI	√				√	
20		CS switch	SPI	√				√	
21		Distance Protection Operated	SPI	√				√	
22		Distance Protection Start	SPI	√				√	
23		Distance Protection Z1 Operated	SPI	√				√	
24		Distance Protection Z3 Operated	SPI	√				√	
25		Distance Protection Z2 Operated	SPI	√				√	
26		OV Protection Operated	SPI	√				√	
27		R Phase Trip	SPI	√				√	
28		RED670 General Trip	SPI	√				√	
29		RED670 pilot wire	SPI	√				√	
30		UV Protection Operated	SPI	√				√	
31		Y Phase Trip	SPI	√				√	
32		PSTO Status of IED2	SPI	√				√	
33		Phy Health2	DPI	√				√	
34		Relay2 comm fail2	SPI	√				√	
35		B Phase Trip2	SPI	√				√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
36		Breaker Failure Protection	SPI	√				√	
37		Line Diff. Protection General Trip	SPI	√				√	
38		OC Protection Start	SPI	√				√	
39		OC/EF Operated	SPI	√				√	
40		OC Protection Operated	SPI	√				√	
41		PCTSF6A B phase	SPI	√				√	
42		PCTSF6A R phase	SPI	√				√	
43		PCTSF6AY phase	SPI	√				√	
44		PCTSF6L B phase	SPI	√				√	
45		PCTSF6L R phase	SPI	√				√	
46		PCTSF6L Y phase	SPI	√				√	
47		R Phase Trip2	SPI	√				√	
48		TCTSF6A B phase	SPI	√				√	
49		TCTSF6A R phase	SPI	√				√	
50		TCTSF6A Y phase	SPI	√				√	
51		TCTSF6L B phase	SPI	√				√	
52		TCTSF6L R phase	SPI	√				√	
53		TCTSF6L Y phase	SPI	√				√	
54		UV Protection Operated	SPI	√				√	
55		Y Phase Trip2	SPI	√				√	
56		Bus Dis Permissive command	DCO		√		√		
57		CB Permissive command	DCO		√		√		
58		Line Dis Permissive command	DCO		√		√		
59		Bus Dis Permissive	SPI	√			√		
60		CB Permissive	SPI	√			√		
61		DC Fail Alarm	SPI	√			√		
62		Line Dis Permissive	SPI	√			√		
63		MFM Signal							
64		R-Y phase Voltage	MVI			√			√
65		Y-B phase Voltage	MVI			√			√
66		B-R phase Voltage	MVI			√			√
67		R phase current	MVI			√			√
68		Y phase current	MVI			√			√
69		B phase current	MVI			√			√
70		Frequency	MVI			√			√
71		PF Average	MVI			√			√
72		R-N Voltage	MVI			√			√

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
73		Y-N Voltage	MVI			√			√
74		B-N Voltage	MVI			√			√
75		VA Total	MVI			√			√
76		VAR Total	MVI			√			√
77		Watts Total	MVI			√			√
78		WH Received	MVI			√			√
79		WH Delivered	MVI			√			√
80		VARH Received	MVI			√			√
81		VARH Delivered	MVI			√			√
1.	ACCB	Phy Health6	DPI	√				√	
2.		ACCB command	DCO		√			√	
3.		ACISO1 command	DCO		√			√	
4.		ACISO2 command	DCO		√			√	
5.		ACCB Position	DPI	√				√	
6.		ACISO1 Position	DPI	√				√	
7.		ACISO2 Position	DPI	√				√	
8.		Phy Health5	DPI	√				√	
9.		86A Operated	SPI	√				√	
10		B Phase Trip	SPI	√				√	
11		Breaker Failure Protection Operated	SPI	√				√	
12		CB Spring Charged	SPI	√				√	
13		CB TC1 Healthy	SPI	√				√	
14		CB TC2 Healthy	SPI	√				√	
15		CB SF6 Lockout	SPI	√				√	
16		CB SF6 Repl. Alarm	SPI	√				√	
17		OC Protection Operated	SPI	√				√	
18		OC Protection Start	SPI	√				√	
19		PCTSF6 A Y Phase	SPI	√				√	
20		PCTSF6A B Phase	SPI	√				√	
21		PCTSF6A R Phase	SPI	√				√	
22		PCTSF6L B Phase	SPI	√				√	
23		PCTSF6L R Phase	SPI	√				√	
24		PCTSF6L Y Phase	SPI	√				√	
25		R Phase Trip	SPI	√				√	
26		TCTSF6A B Phase	SPI	√				√	
27		TCTSF6A R Phase	SPI	√				√	
28		TCTSF6A Y Phase	SPI	√				√	
29		TCTSF6L B Phase	SPI	√				√	

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
30		TCTSF6L R Phase	SPI	√				√	
31		TCTSF6L Y Phase	SPI	√				√	
32		Y Phase Trip	SPI	√				√	
33		Relay comm fail	SPI	√				√	
34		86A Permissive Command	DCO		√		√		
35		86B Permissive Command	DCO		√		√		
36		CB Permissive command	DCO		√		√		
37		86A Permissive	SPI	√			√		
38		86B Permissive	SPI	√			√		
39		CB Permissive	SPI	√			√		
40		CS Switch	SPI	√			√		
41		DC Fail Alarm	SPI	√			√		
1.	BUSBAR	PhyHealth11	DPI	√				√	
2.		ZnA BB Differential Protection Trip	SPI	√				√	
3.		ZnB BB Differential Protection Trip	SPI	√				√	
4.		LTO BLOCKED Command	DCO		√		√		
5.		B1 TO B2	DPI	√			√		
6.		B2 TO B1	DPI	√			√		
7.		L1 TO L2	DPI	√			√		
8.		L2 TO L1	DPI	√			√		
9.		LTO Blocked	SPI	√			√		
10		BTO Blocked	SPI	√			√		
1.	OLTC-1	Tap Selec CS	DPI	√			√		
2.		Tap Raise/Lower	RCO		√		√		
3.		Auto	SPI	√			√		
4.		DC Fail Alm	SPI	√			√		
5.		Incomplete/Struck	SPI	√			√		
6.		Lower limit Reached	SPI	√			√		
7.		Manual	SPI	√			√		
8.		OLR Trip	SPI	√			√		
9.		SCADA	SPI	√			√		
10		Upper limit Reached	SPI	√			√		
1.	OLTC-2	Tap Selec CS	DPI	√			√		
2.		Tap Raise/Lower	RCO		√		√		
3.		Auto	SPI	√			√		
4.		DC Fail Alm	SPI	√			√		
5.		Incomplete/Struck	SPI	√			√		
6.		Lower limit Reached	SPI	√			√		

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
7.		Manual	SPI	√			√		
8.		OLR Trip	SPI	√			√		
9.		SCADA	SPI	√			√		
10.		Upper limit Reached	SPI	√			√		
1.	FIRE	FIRE POPROT SV	SPI	√			√		
2.		FIRE PORT OPTD	SPI	√			√		
3.		FIRE PORT STATUS	SPI	√			√		
1.	UPS-1 & UPS-2	UPS Input Voltage	SPI	√			√		
2.		UPS Input Frequency	SPI	√			√		
3.		UPS Input Power Factor	SPI	√			√		
4.		UPS Output Voltage	SPI	√			√		
5.		UPS Output Frequency	SPI	√			√		
6.		UPS Output Power Factor	SPI	√			√		
7.		UPS Rectifier Off	SPI	√			√		
8.		UPS Rectifier Over Temperature	SPI	√			√		
9.		UPS Rectifier Fail	SPI	√			√		
10.		UPS Inverter Off	SPI	√			√		
11.		UPS Inverter Over Temperature	SPI	√			√		
12.		UPS Inverter Fail	SPI	√			√		
13.		UPS Load On Bypass	SPI	√			√		
14.		UPS Overload	SPI	√			√		
15.		UPS Battery Voltage	MVI			√	√		
16.		UPS Battery Charger Current	MVI			√	√		
17.		UPS Battery On Load	SPI	√			√		
18.		UPS Battery Over Temperature	SPI	√			√		
1.	RTU	RTU power Supply 1 Status	DI	√			√		
2.		RTU Power Supply 2 Status	DI	√			√		
3.		RTU Panel Door Status	DI	√			√		
4.		RTU Local/Remote Switch Status	DI	√			√		
5.		RTU CPU Module, Communication Module, I/O Module Status	DI	√			√		
6.		Communication Card Failure signal	DI	√			√		
7.		Communication Rack power supply -1 failure status	DI	√			√		
8.		Communication Rack power supply -2 failure status	DI	√			√		
9.		Communication switch-1 status	DI	√			√		

SL No	Bay	Signal Name	Signal Type	Event Type			Hardwired Signal	Soft Signal Via IEC-61850	MFM Via Modbus
				DI	DO	AI			
10.		Communication switch-2 status	DI	√			√		

SCADA Signal List for 25kV GIS Switching Equipment

Sr. No	System (OHE/ASS/RSS)	Sub-System (Feeder/Bay Code)	Equipment Code (Unique No)	Signal Description (Event Text)	Event Type DI/DO/AI	Normal State	Alarm State	0-None, 1-Visual, 2-Audio Visual, 3-Critical
1.	OHE	Voltage Transformer/Sensor	PTs	Voltage	AI			
2.	OHE	Incomer	CB	Local/Remote mode status	DI	Remote	Local	P1
3.	OHE			110V DC Control Supply Status	DI	Normal	Fail	P2
4.	OHE			Breaker close Indication	DI	Close		P0
5.	OHE			Breaker open Indication	DI	Open		P0
6.	OHE			SCADA Permissive Indication	DI	Banned	Permitted	P1
7.	OHE			SF6 pressure low status	DI	Normal	Low	P2
8.	OHE			Control Ac supply fail	DI	Normal	Fail	P2
9.	OHE			Isolator Position Indication Open	DI	Open		P0
10.	OHE			Isolator Position Indication Close	DI	Close		P0
11.	OHE			CB spring Status	DI	Charged	Discharged	P2
12.	OHE			Earth Switch Position Indication Open	DI	Open		P0
13.	OHE			Earth Switch Position Indication Close	DI	Close		P0
14.	OHE			Breaker drive Status	DI	Normal	Fail	P2
15.	OHE			VT in service status	DI	Service	test	P2
16.	OHE			CB compartment SF6 gas pressure low stage-1	DI	Normal	Low	P2

Sr. No	System (OHE/ASS/RSS)	Sub-System (Feeder/Bay Code)	Equipment Code (Unique No)	Signal Description (Event Text)	Event Type DI/DO/AI	Normal State	Alarm State	0-None, 1-Visual, 2-Audio Visual, 3-Critical
17	OHE			CB compartment SF6 gas pressure low stage-2	DI	Normal	Trip	P2
18	OHE			SF6 high pressure compartment	DI	Normal	Trip	P2
19	OHE			Trip circuit supervision	DI	Normal	Alarm	P2
20	OHE			Surge counter	DI	Normal	fail	P2
21	OHE			over current optd stage wise	DI	Normal	Operated	P2
22	OHE			Breaker Failure Protection Status	DI	Normal	Operated	P2
23	OHE			Earth fault	DI	Normal	Faulty	P2
24	OHE			Under Voltage Protection Status	DI	Normal	Operated	P2
25	OHE			Over Voltage Protection Status	DI	Normal	Operated	P2
26	OHE			Reverse power protection	DI	Normal	Operated	P2
27	OHE			Master trip relay optd	DI	Normal	Operated	P2
28	OHE			CB Open Command	DO			P0
29	OHE			CB Close Command	DO			P0
30	OHE			CB SCADA Permissive Command	DO			P0
31	OHE			Isolator Close Command	DO			P0
32	OHE			Isolator Open Command	DO			P0
33	OHE			Lockout relay reset cmd	DO			P0
1	OHE	Out-going	CB	Local/Remote status	DI	Remote	Local	P1
2	OHE			Control AC Supply Status	DI	Normal	Fail	P2
3	OHE			110V DC Supply Status	DI	Normal	Fail	P2
4	OHE			CB Position Indication Close	DI	Close		P0
5	OHE			CB Position Indication Open	DI	Open		P0

Sr. No	System (OHE/ASS/RSS)	Sub-System (Feeder/Bay Code)	Equipment Code (Unique No)	Signal Description (Event Text)	Event Type DI/DO/AI	Normal State	Alarm State	0-None, 1-Visual, 2-Audio Visual, 3-Critical
6	OHE			SF6 pressure low status	DI	Normal	Low	P2
7	OHE			CB SCADA Permissive Indication	DI	Banned	Permitted	P1
8	OHE			Isolator Position Indication Open	DI	Open		P0
9	OHE			Isolator Position Indication Close	DI	Close		P0
10	OHE			Earth Switch Position Indication Open	DI	Open		P0
11	OHE			Earth Switch Position Indication Close	DI	Close		P0
12	OHE			Breaker drive Status	DI	Normal	Fail	P2
13	OHE			VT in service status	DI	Service	test	P2
14	OHE			CB spring Status	DI	Charged	Discharged	P2
15	OHE			CB compartment SF6 gas pressure low stage-1	DI	Normal	Low	P2
16	OHE			CB compartment SF6 gas pressure low stage-2	DI	Normal	Trip	P2
17	OHE			SF6 high pressure compartment	DI	Normal	Trip	P2
18	OHE			Over current optd stage wise	DI	Normal	Operated	P2
19	OHE			Breaker Failure Protection Status	DI	Normal	Operated	P2
20	OHE			Earth fault	DI	Normal	Faulty	P2
21	OHE			Di/dt	DI	Normal	Operated	P2
22	OHE			Master trip relay operated	DI	Normal	Operated	P2
23	OHE			Voltage based over current	DI	Normal	Operated	P2
24	OHE			Distance protection optd(zone wise)	DI	Normal	Operated	P2
25	OHE			PFR optd	DI	Normal	Operated	P2
26	OHE			Voltage – Restrained overcurrent	DI	Normal	Operated	P2

Sr. No	System (OHE/ASS/RSS)	Sub-System (Feeder/Bay Code)	Equipment Code (Unique No)	Signal Description (Event Text)	Event Type DI/DO/AI	Normal State	Alarm State	0-None, 1-Visual, 2-Audio Visual, 3-Critical
27	OHE			CB Open Command	DO			P0
28	OHE			CB Close Command	DO			P0
29	OHE			CB SCADA Permissive Command	DO			P0
30	OHE			Isolator Close Command	DO			P0
31	OHE			Isolator Open Command	DO			P0
32	OHE			Lockout relay reset	DO			P0
33	OHE			Under Voltage Protection Status	DI	Normal	Operated	P2
34	OHE			Over Voltage Protection Status	DI	Normal	Operated	P2
1	OHE	BUS Coupler	BC	Local/Remote mode status	DI	Remote	Local	P1
2	OHE			110V DC Control Supply Status	DI	Normal	Fail	P2
3	OHE			Breaker Position Indication Close	DI	Close		P0
4	OHE			Breaker Position Indication Open	DI	Open		P0
5	OHE			Breaker SCADA Permissive Indication	DI	Banned	Permitted	P1
6	OHE			Control AC Supply Status	DI	Normal	Fail	P2
7	OHE			SF6 pressure low status	DI	Normal	Low	P2
8	OHE			Isolator Position Indication Open	DI	Open		P0
9	OHE			Isolator Position Indication Close	DI	Close		P0
10	OHE			Earth Switch Position Indication Open	DI	Open		P0
11	OHE			Earth Switch Position Indication Close	DI	Close		P0
12	OHE			Breaker drive Status	DI	Normal	Fail	P2
13	OHE			VT in service status	DI	Service	test	P2

Sr. No	System (OHE/ASS/RSS)	Sub-System (Feeder/Bay Code)	Equipment Code (Unique No)	Signal Description (Event Text)	Event Type DI/DO/AI	Normal State	Alarm State	0-None, 1-Visual, 2-Audio Visual, 3-Critical
14	OHE			CB spring Status	DI	Charged	Discharged	P2
15	OHE			CB compartment SF6 gas pressure low stage-1	DI	Normal	Low	P2
16	OHE			CB compartment SF6 gas pressure low stage-2	DI	Normal	Trip	P2
17	OHE			SF6 high pressure compartment	DI	Normal	Trip	P2
18	OHE			Over current optd	DI	Normal	Operated	P2
19	OHE			Breaker Failure Protection Status	DI	Normal	Operated	P2
20	OHE			Earth fault	DI	Normal	Faulty	P2
21	OHE			Under Voltage Protection Status	DI	Normal	Operated	P2
22	OHE			Over Voltage Protection Status	DI	Normal	Operated	P2
23	OHE			Master trip relay operated	DI	Normal	Operated	P2
24	OHE			Reverse power protection	DI	Normal	Operated	P2
25	OHE			Isolator Close Command	DO			P0
26	OHE			Isolator Open Command	DO			P0
27	OHE			Lockout relay reset	DO			P0
28	OHE			Breaker Close Command	DO			P0
29	OHE			breaker Open Command	DO			P0
30	OHE			Breaker SCADA Permissive Command	DO			P0

ANNEXURE-A8**1 EOT CRANES****1.1. GENERAL DESCRIPTION**

The specification covers the design, manufacture, supply, installation, testing and commissioning of Electric Overhead Travelling (EOT) Cranes to be installed in the RSS

1.2. TECHNICAL CHARACTERISTICS

The technical parameters of the EOT cranes are:-

1.2.1. Main characteristics

Which includes:-

The capacity (nominal load),

- ☐ Operating speeds in all three directions at low speed (LS) and high speed (HS),
- ☐ Dimensional characteristics,
- ☐ The movements of hoisting, traversing and long travelling shall be operable simultaneously,
- ☐ Pendant control and
- ☐ Radio remote control

1.2.2. Mechanical part**1.2.2.1. Crane Bridge**

The crane should be rigid, robust and of sturdy construction. The crane bridge shall comprise of double girders of the plate box type. The connection between crane Girder and End Carriages should be through High strength frictional grip bolts with spacer washer. The inner faces of plate joints containing spacer washers must be given one primer coating with 60 micron layer thickness.

The crane bridge should be carried on end trolleys with double-flanged solid casted wheels of spheroidal graphite impregnated material. The minimum end clearance on each side of the long travel wheels should be 7.5mm. The wheels should be mounted inside the End Carriage and

can be conveniently removed, if required. For Underslung type EOT cranes of Inspection bay, flangeless wheels are to be considered for cross and long travel.

Suitable jacking pads should be provided on each end carriage for jacking up the crane while changing track wheels. These jacking pads should not interfere with replacement of long travel track wheels.

The end carriages should be fitted with suitable safety stops to prevent the crane from falling more than 25mm in the event of breakage of track wheel, bogie or axle. These safety stops should not interfere with the removal of track wheels. The diameter of the motorised wheels and the steel grade must be studied to obtain, in all load configurations, perfect braking without any slide. Each end carriage shall be provided with rubber stops adapted to the end buffers.

1.2.2.2. Trolley frame and hoist

The trolley frame of all the double girder EOT cranes should be welded rolled steel section, designed to transmit the load to the bridge rails without undue deflection.

The trolley wheels of all double girder EOT cranes should be double flanged. The Wheel bearings should be either grooved ball bearing or taper roller bearings as per design specifications.

The top of the trolley frame should be plated (chequered plate) all over at the top, except for opening(s) required for the ropes to pass through. The opening in the trolley frame should be such as to keep the ropes at a safe distance from any part of the trolley frame or equipment, to prevent damage at all positions of the bottom block.

The trolley should be fitted with substantial safety stops to prevent the trolley from falling more than 25mm in the event of breakage of track wheel, bogie or axle. These safety stops should not interfere with the removal of wheel.

The trolley frame/hoist shall be provided with rubber stops designed to absorb the kinetic energy in the event of a braking fault. Stops shall be designed for a trolley running at high speed under a nominal load. The hoist shall be provided with manual brake release in the event of power failure.

1.2.2.3. Rails

The rails shall be designed with the consideration of building expansion joints. The bridge rails shall be Square / Rectangular bar of EN8/SNT52 Material. Rail stops welded should be provided to prevent creep in the longitudinal direction. These rails to be directly welded on the Gantry Girders.

Since Under slung cranes of Inspection bay travels on bottom flange of the runway beam, LT Rails are not required for these cranes. However, the PST contractor should confirm the flange width and thickness of the runway beams to the structural PST contractor at the stage of building drawings approval.

1.2.2.4. Rail wheels

The rail wheels of all EOT cranes other than that of Inspection bay should be double-flanged with straight tread. They shall be capable of taking misalignments in span as per VDI 3576, Class II specifications. These wheels shall be of spheroidal Graphite impregnated Cast Iron material to have minimum hardness of 22 HRC. The Wheel Blocks to be connected to End Carriage through Pin connection & circlip locking. Wheels should be with splined hub profile to DIN 5480, Residual flange indicator, Dampening element and protected internal bearing arrangement featuring Tapered Roller. Wheel bearings to be lubricated for life.

1.2.2.5. Rope drums

The rope drum shall be designed to withstand the compressive stresses caused by the wound on rope and the bending stress due to beam action of the drum. The drum shall be designed to take the entire length of the rope in a single layer. Free extra turns shall also be provided. The drum shall be flanged at both ends.

Cranes shall be designed with number of rope falls varying with lifting capacity as per details given below:

Upto 15.0 tonnes - 4 falls

Rope drums should be with Rope guide made of tough plastic offering smooth rope lead-in by means of hardened pressure rollers mounted on Anti-friction bearings. Inclined pull upto 40 without touching the Rope guide should be possible.

1.2.2.6. Wire ropes

The Wire rope should be of reputed make and designed according to FEM 9.661 with tensile strength more than 1570 N/mm². Wire ropes should be with Steel core IWRC.

1.2.2.7. Gearing

The gearing in all motions should be of suitable case-carburising low carbon alloy steels and should conform to relevant Indian/International standards. They shall generally be in accordance with IS: 4460-1967(or latest) or relevant International standard like DIN. All gears and pinions must be made from forged blanks only. All gears should be hardened and profile ground for longer life and silent operation.

At all stages only helical gears should be used, except in planetary gearboxes, which can be spur type. Overhung or split gears and pinions should not be used. In addition, worm wheels and bevel gears must not be used.

1.2.2.8. Gearboxes

All gearboxes shall be of completely enclosed splash lubricated type. All gearboxes shall be oil tight and sealed with compound or gasket. All gear shafts shall be supported in bearings mounted in the gearboxes. Gearboxes should be made either of high quality pressure die cast aluminium alloy or of grey cast iron housing. All gearboxes shall be stress relieved. Adequate radial clearances between the gearbox inner surface and outside diameter of the gears shall be ensured. The facial clearance between the inner surface of the gearbox and the face of the nearest gear/pinions shall be at adequate.

These should be of a modular, integral design. Motors may be either flange-mounted or foot mounted, or a combination of the two. In case of foot mounted motors, split type gearboxes shall also be acceptable. The gearboxes should also be splash lubricated type. Alternatively, VVVF controlled, directly coupled motors can also be offered.

1.2.2.9. Drives

The wheels of each end carriage should be driven by independent synchronized drive motors mounted near each end carriage. A separate cross traverse motor should be used for cross traverse drive through a

suitable gearbox.

Alternatively, Two Step Variable voltage variable frequency (VVVF) control of adequate capacity for all the motions of the crane can also be provided. Any alternative design of international standard may also offer VVVF drives of Siemens, ABB, Demag, L&T, Allen Bradley, Vectron shall be used.

1.2.2.10. Brakes

The hoisting motion shall be provided with fail-safe electro-hydraulic thruster brakes. Disc brakes are also acceptable. The LT & CT motion may have DC/AC electro-magnetic disc brakes in case of flange mounted motors where integral gearboxes are being offered, to derive the maximum advantage in terms of compactness and weight, but if the motors are not flange-mounted then thruster brakes should be used. In case of Thruster Brakes, the maximum braking torque to arrest long travel and cross traverse motions should not less than 100% of full load torque for each brake. For hoist motion, two brakes should be used and the braking torque for each brake should not be less than 125% of full load torque. One of the two hoist brakes shall be applied with a time lag of 3 seconds in relation to the first. Thruster brakes should also be with Double shoe brakes for each drive. Brakes should be mounted on the input pinion shaft of all gearboxes. The brake shoe should be of hinged type. Brake levers should be forged and hinge pins should be provided with steel bushes at the bearing points. Brake drums should be of forged or caststeel and should be completely machined. Width of brake drum should be about 10mm more than the width of brake shoe on each side.

1.2.2.11. Couplings

In case of separate drive mechanism, motor shafts for MH/AH shall be connected to gearbox input extension shaft through flexible gear coupling. For driving the hoist drum gear type flexible coupling shall be used between, the ropes drum and hoist gear box, where the hub should not be integral with the output shaft, so as to avoid replacement of the whole shaft whenever there is wear and tear in the coupling. Solid couplings should not be used.

All couplings shall be of medium carbon steel and shall be designed to suit the maximum torque that can be developed. Hardness of geared portion in the gear coupling shall be more than 250 BHN. Bolted connections shall

be easily accessible for inspection and tightening.

1.2.2.12. Rope sheaves

All sheaves should be of cast/forged steel, they should be identical, with the exception of the equaliser sheave. The equaliser sheave should be mounted above the trolley floor and should be easily accessible and removable from the trolley floor level. The equaliser sheave should be arranged to turn and swivel in order to maintain rope alignment under all circumstances. Sheave grooves should be smooth finished for getting increased rope life. The supplier should further ensure that wire ropes are parallel with each other.

1.2.2.13. Bearings

Ball and roller anti-friction bearings shall be of only reputed makes like NBC, SKF, FAG, NORMA, NRB, NTN and KOYO.

For long and cross traverse wheels, bearings should be either grooved ball bearing or taper roller bearings as per design specifications shall be used. Bush bearings should not be used at any location.

Rated life of ball and roller bearings should not be less than the total life in working hours given in accordance for a particular class of duty.

Independent bearing housings on long shafts are split on the shaft centre line to permit easy removal of the shaft. The bottom surface of all bearing pedestals should be machined, and should bear upon a machined surface.

1.2.2.14. Lifting hook

The hook shall be secured to a pulley block system with pulleys designed according to the characteristics of the wire ropes. The pulley block system casing shall be provided with two proper grips.

Standard plain shank type trapezoidal section hooks should be used. These hooks should conform to the relevant Indian Standard Specifications IS: 15560 (latest) / DIN standard 15401.

Hooks should be mounted on grease lubricated anti-friction thrust bearings and a protective skirt should be fitted to prevent rotation of the hook. The hook block should have handle recess to provide improved safety against hand crushing. The bottom block must be of enclosed design. The rope sheaves of the bottom blocks must be protected with

covers, so that the operator's hand cannot be jammed between the rope sheaves and the rope. The Rope sheaves should be self-adjustable type during Hoisting motion to accommodate the Wire Rope. The hook shall be fitted with a safety catch of spring-loaded type.

1.2.2.15. Buffer

Spring loaded or other suitable buffers should be fitted on the four corners of the crane and also at the four ends of the bridge girders. Buffers should be rigidly bolted in place, preferably along the centre line of the crane rail or trolley rail as the case may be. All buffers should have sufficient energy absorbing capacity to stop the bridge or trolley in either direction when travelling at its rated speed.

1.2.2.16. Lubrication

Individual/Group lubrication, one for each of the end carriage and one for the trolley platform, should be provided for all grease-lubricated bearings, parts of the hoist, cross traverse and long travel. The grease battery nipples should be located to facilitate regular greasing by the operator with standard equipment. All gears and bearings enclosed inside gearboxes should be splash lubricated. Bottom blocks and pedestal bearings should have independent greasing points. All lubricating pipe work should be securely fixed and protected from damage, and be accessible throughout. A lubricating chart should be provided in the manual, indicating all lubrication points, the type of lubricants required and the recommended frequency of lubrication. These details should be repeated, and amplified, in the Maintenance Manual.

1.2.2.17. Maintenance Platform

Each Double Girder crane shall include one maintenance walkway installed along the crane box girder structures & one Short platform on other side of the crane. Walkway shall be of a length equal to that of a box structure and the other shall be of a length equal to that of the traversing trolley. Crossover from one walkway to the other shall be via a platform, mounted on the hoist trolley. Plating shall be of the anti-skid type. Walkways shall be provided with guardrails designed in accordance with

safety standards. Whereas for under slung crane maintenance platform is not applicable.

1.2.3. Electrical part

The PST contractor shall carry out all electrical work from power supply switch to the cranes. The available electrical power supply is 360-440V, 50 + 3% Hz, three-phase, 4-wires. The equipment and gear to be supplied mainly includes:

- ☐ one latchable isolating switch and MCCB,
- ☐ down shop leads,
- ☐ electric switchboard and control panel ,
- ☐ various motors,
- ☐ power and control wiring,
- ☐ limit switches,
- ☐ the lighting (2Nos. H.P.M.V Under bridge lamps - 400W)- In case of double girder cranes only,
- ☐ the control switch

1.2.3.1. Latchable isolating switch

It is provided for maintenance purpose and shall impede any movement of the EOT Crane when Maintenance work is in progress.

1.2.3.2. Down Shop Leads

The down shop leads shall be of enclosed type with copper conductors.

The conductor system shall be compact in construction finger safe to IP-23. The conductor material shall be insulated by a high impact gloss finish PVC compound which shall have a step/groove shrouded all along its length for effective moulding of the conductor system.

The conductor section shall be minimum four mtrs. in length to be jointed with moulded joint of the same material as the conductor and these

conductors shall be supported by way of a single piece moulding, four pole hanger with single bolt fixing.

The current collector trolley running inside the enclosure should be with spring loaded sliding contacts offering positive contact with copper conductor. The cable from current collector trolley should be totally insulated, fully enclosed and double insulated within the collector arm with a proven performance.

Necessary wearing components for maintenance during DLP shall be provided. The PST contractor shall size the copper section of the conductor in accordance with the necessary power, and voltage drop requirements with the approval of the Employer.

The bays are provided with power supply to the down shop leads with four sets of power-on indicator lights. The power supply for crane will be provided at workshop working level through TPN MCCB.

The cabling from TPN MCCB to down shop leads shall be in crane scope of work. Down shop leads shall be connected to power supply at single / multiple points, as per the design requirements.

1.2.3.3. Switchboards and gear

Control gear shall be mounted in one or more switchboards depending on the type of EOT Crane. The protection index shall be IP 54.

The trip circuit of the circuit breaker shall be designed such that it should prevent the circuit breaker from being enclosed when main contactor of any of the motions has failed to open, although the corresponding controller has been brought to OFF position. Suitable protective features to trip the circuit breaker with the operation of limit switches and emergency push buttons shall also be provided. For protection of each drives, motor against over loads adjustable inverse time lag manually reset electro-magnetic, type relays shall be provided for each motor. Alternatively, electronic type relays shall be acceptable. These relays shall be mounted in respective contactor panels and shall be set to trip the circuit of motion being controlled when current exceeds 200% of normal value for more than 10 seconds. Each motor feeder shall be protected with

no volt trip device & short circuit, and with instantaneous trip current sensitive type single phasing cum phase reversal preventor. Isolating switches fitted with protection shall be provided for the following branch circuits:

- (a) Lighting and hand lamp socket outlets
- (b) Control circuit.

Each control circuit branch to every contactor panel shall be provided with facility for isolation and protection against short circuits and sustained high overloads by means of appropriately rated miniature circuit breaker.

The electrical switchboard shall be key locked. The door shall include a 3-position switch provided for no-load testing of control circuits and shall be connected to the cabinet via an earth braid.

All terminals and wiring shall be marked in accordance with the electrical diagram.

1.2.3.4. Control Pendant

The controls shall be given from a push-button control pendant, which shall be:

- > sealed, insulated to IP65 and unbreakable,
- > be capable of moving along the EOT Crane independently from the movement direction of the hook,
- > be suspended with a stainless-steel wire
- > The pendant control shall be capable of withstanding rough handling without being damaged. The cover shall be firmly secured & made out of Nylon fiber.

The function of the push buttons shall be identified by means of engraved labels. The various types of push buttons used are as follows:-

- > Safety means shall be provided to prevent inadvertent operation from floor while maintenance work is being carried out on the crane.
- > Adequate guards shall be provided to prevent accidental contact of pendant ropes or holding wire rope/chain with cross traverse.
- > released, not held, for all movements and for the hooters,
- > held for switching on and lighting,

- > turn to unlock for the emergency stopping.

1.2.3.5. Radio Remote Control

The wireless control facility shall incorporate control of movements in all directions, with speeds identical to those provided for the pendent control.

The facilities to be provided shall incorporate but need not to be limited to the operations features listed below:

- > Emergency stop button
- > Emergency alarm button
- > Normal ON/OFF button
- > Low/High speed button
- > Directional movement control buttons
- > Radio/Pendent control selection buttons
- > Overall, weight of remote control hand set (transmitter) not to exceed 0.5 kgs. Approx.

The system shall be so designed that in the event of mal-function it should be possible for the user to switch over to pendent control through suitable by pass switch facility. The general scope of supply Radio Remote Control equipment shall be as follows:

- ☐ 1 no. Transmitter-Push button type
- ☐ 1 no. receiver
- ☐ 1 no. Antenna and cable
- ☐ Two sets of Alkaline battery size AA

The transmitter shall be provided with a shoulder belt and shall be in IP65 enclosed. The system shall be microprocessor based and shall have watchdog circuit. The range of operation should be 40 meters minimum.

The crane supplier shall be responsible for commissioning the system.

Tenderer shall ensure adequate supply of spares and availability of maintenance spares support within the country.

Equipment supplied should be certified by internationally recognised inspection agency.

1.2.3.6. Contactors

All contactors shall be of AC 4 Class of duty with rating sufficiently higher

than the full load current of the respective motors at the specified duty cycle. The directional contactors of all motions shall be suitably interlocked for correct sequence of operation. Electrical & mechanical life of the contactors shall be indicated. For AC 4 Class of duty Electrical life shall be minimum 2,00,000 cycles of operations. The contactors shall have high contact reliability with preferably double break parallel bridge contact and facility of time saving termination. All contactors shall be of Telemecanique, ABB, Siemens, L&T and Cutler Hammer make. Test certificate of the manufacturers shall be submitted in support of life and rating of the contactors.

1.2.3.7. Limit switches

All hoist motions shall be provided with limit switches to prevent crane from over hoisting and over lowering. Limitation of the motions at the upper and lower Hook positions should be effected by Geared Limit switch, provided with 4 contacts. The design should be such that the limits can be set as per the requirements during crane installation at site.

Two stages Limit switch for hoist cross and long travel motion shall be supplied installed and wired by the manufacturer.

1.2.3.8. Control panel

Variable voltage variable frequency control (VVVF) if considered, should be of adequate capacity for all the motions of the crane shall be provided. VVVF drive of Siemens, ABB, L&T, Allen Bradley make shall be used. Independent AC variable frequency control for main hoist, aux. Hoist, CT & LT shall be used by using independent variable voltage variable frequency drives. However, common controller for both the motors of LT may be used.

The components inside the Control panel should be mounted in such a way that all the components are easily accessible. The clearance between cable tray and each component should be minimum 25mm.

GA drawing of control panel should indicate internal layout of the components. Instrument cutouts should be exact and without burrs or unevenness. Location of outgoing terminals should be minimum 100mm above the gland plate. Gland plate should be sufficient to accommodate

outgoing cables.

Proper stiffeners should be provided to avoid buckling and unevenness. Control panel should have self adhesive type gasketing arrangement. Control panel box and base plate should have identification label bearing details of project, electrical drawing number along with revision number.

Minimum steel thicknesses to be used are:

- Base plate –2.0 mm
- Front Facia –2.0 mm
- Other sides –2.0 mm/1.6mm
- Frame –2.0 mm

All power and auxiliary contactors, individual overload relay shall be mounted in sheet steel cubical with lockable-hinged doors. The door hinges shall be of such type that during the repair works inside the panel the entire door can be lifted out and placed away enabling better access inside the panel. A common panel with separate compartment for each motion shall be acceptable. Interiors of panel shall be dust and vermin proof. Panels shall be front wired with readily accessible terminal blocks for making connections in the external equipment. Panels shall be pre-wired into terminal strip. Single core, copper conductor shall be used for control circuit wiring in the panel. All the equipment shall be so mounted in panel as to enable its easy removal/replacement from the front.

1.2.3.9. Cabling

Control wiring and signal wiring should be separate as far as possible. Phase control wiring should be 1.5 Sq. mm gray while neutral wiring should be black in colour. Power wiring should be minimum 2.5 Sq. mm size and R,Y,B colour coated for R,Y,B phases. Maximum loading of PVC cable should be 60% of cable tray capacity. Wire bends should not be sharp to damage the conductors. Proper support for outgoing cables should be provided with proper Ferruling. Wiring more than 5 cm length should not be exposed. Wiring should be properly bunched or spiralled. Wiring should run parallel only, no crossing of two wires is permitted. Common point of star connected current transformers should be earthed. Where ever required, a separate instrument earth should be provided, which is

separate from main earth. Earthing can be done as per cable size and application requirement, also creepage distance could be decided as per IEC standard / switch gear manufacturer requirement. Control and power links between the EOT Crane Bridge and the hoist are made of flat cable, laid as a garland, with appropriate carriers. Any cables exiting from a steel tube must be protected by an insulating end fitting. Power cable shall be of FRLSH XLPE type. Labels of permanent nature shall be provided on supports of all switches, fuses, contactors, relays etc, to facilitate identification of circuits and replacement. All panels, controllers, resistors etc. shall be properly marked for each motion. All power control cable, lighting and other cables shall be ferruled at both end as per cables numbers indicated in the supplier's drawing. All equipment terminals shall also to be marked likewise.

1.2.3.10. Motors

Motors shall be of the asynchronous or squirrel cage type with a built-in electromechanical or magnetic brake. The ingress protection level of motors shall be IP55. Motor selection for lifting and travel applications should be according to rule FEM 9.683. The motors must be suitable for the operating conditions and ensure safe operation under related conditions. All motors shall have insulation class B. The criteria for motor selection should be as below:

- ☐ Required power – the thermal power is also included in these required powers.
- ☐ Maximum rated torque and maximum acceleration torque.
- ☐ Cyclic duration factor.
- ☐ No. of cycles / hour.
- ☐ Type of control (type of braking)
- ☐ Speed regulation.
- ☐ Degree of protection.
- ☐ Ambient Temperature.

This brake shall be applied automatically in case of power failure during lifting or travel.

1.2.3.11. Lighting

For all double girders EOT cranes other than that of Inspection bay should have high bay light fitting with metal halide lamps of 400 W and associated control gear shall be securely fitted at two different locations below the crane platform. These units shall be supplied with 230 V via a contactor controlled from a switch on the pushbutton pendant. A switch for the tubes shall be provided on the walkway.

Tool Receptacle shall be provided on crane platform – 2 Nos. sockets (1 No. – Single phase, 20Amps and 1No. – Three Phase, 32 Amps) to provide power supply for maintenance purpose.

1.2.3.12. PROTECTION AND SAFETY

In addition to the various recommendations enumerated in the previous paragraphs, the PST contractor shall include the protection systems scheduled in the standards and consider the following recommendations:

- all metal parts shall be earthed,
- all movements (lifting, forwards/ reverse, traversing) shall include limit switches, The lifting movement shall be fitted with:
 - └ an over travel switch cutting off the power circuit which may be reset from the crane walkway,
 - └ a load limiter, which cuts off the power supply to all movements except lowering
 - └ A buzzer to warn the persons working near the crane operating zone when crane is in working condition.

1.2.3.13. STANDARDS

The entire supply shall satisfy the requirements of Indian Standards mentioned below or equivalent International/European/British standards/ DIN Standards and regulations in force:

- IS 3177 : 1999 – Indian Standard Code of practice for EOT Cranes
- IS 807 : 1976 – Indian Standard code of practice for design, manufacture, erection and testing(structural portion) of cranes and

hoists

- IS 3938 : 1979 – Indian Standard code for electric wire rope hoists
- IS 2266 : 1976 – wire ropes
- IS 4460: 1967 - gears
- BS 466: specification for power driven overhead travelling cranes, semi-goliath and goliath cranes

For general use:

- BS 2573 : Part 1 & 2 - Rules for design of cranes BS 5395 - Stairs, ladders and walkways
- DIN 15018 – Crane classification
- DIN 15401 – Lifting hooks for lifting appliances FEM 9.683 – selection of lifting and travel motors.
- FEM 9.661 – Rules for design of series lifting equipment
- DIN 15020 – Principles relating to Rope Drives.

1.2.3.14. FINISH

Paintwork

Preparatory works prior to painting:

Outsides: brushing, degreasing, grit blasting. Copper Slag blasting to the second quality finish (Swedish Standard grade SA 2.5) and blowing clean.

Hollow bodies: these areas shall be treated prior to assembly by applying a coat of anti- corrosion paint.

The thickness of this coat after drying shall not be less than 180 microns.

Painting:

External parts and ancillary parts shall receive:

- Type: Primer cum finish paint
- Make: Hempel fast dry 45410/ sigma cover 350/ intergard 345
- Nos. of coat: 2Nos.
- Gloss Level: Semi Gloss (40-50%)
- Total DFT: 125 Micron

The paints to be applied on walkways, access ladders and handrails shall have a good abrasive resistance. All equipment shall be painted golden yellow (RAL 1004). On site, the PST contractor shall touch-up paintwork which may be made necessary by equipment installation.

1.2.3.15. Unpainted parts

All friction parts or parts which must remain polished shall be coated to protect them from corrosion until equipment start-up.

1.2.3.16. Identification

Two identification plates shall be fixed to each crane on either side of the main structure.

These Identification plates shall indicate:

- ☐ Safe working load in Tonnes
- ☐ the year of manufacture,
- ☐ the unit item number.

The Constructor's identification plate may be affixed.

- ☐ All nuts, bolts, washers etc shall be GI except where provided otherwise.

1.2.3.17. CHECKS AND TESTS

In-manufacturer's-plant

During manufacture, and prior to delivery, verifications and checks shall be carried out in order to ensure that the supply is in accordance with the technical specification and with the approved design documents.

All quality checks shall be carried out, as required, during manufacture on the PST contractor's or on the sub-PST contractor's premises.

The PST contractor shall provide for quality check of supplies on his sub-PST contractor's premises prior to delivery of these supplies to his workshops.

Operation of safety and protection devices shall also be checked. The PST contractor shall also carry out the following practical tests:

- the various operating configurations with no load,
- insulation,
- proper operation of dynamic tests including:
 - verification of speeds,
 - crane behavior during start-up, acceleration, deceleration and braking.
 - In particular, the efficiency of the brakes, limit switches, load limiters, good collection of power and the various currents, heating of electrical and mechanical devices, etc. shall be checked.

These tests shall be carried out only on forward, reverse and lifting movements. Traversing movements shall be tested on the site.

1.2.3.18. At-Site

After assembly and erection of the EOT Cranes at site, all tests mentioned in para 6.1 shall be carried out in presence of a representative of the Employer. In addition, the tests pertaining to the traversing movement and the verification of the anti-collision devices shall be carried out after assembly on the site along with the load test at 100% loading and over load test at 125% loading for determining crane Girder deflection. After these tests, the load limiter shall be adjusted to its normal value and tested. The Main PST contractor shall be responsible for arranging loads at site for load testing.

TRAINING

The PST contractor shall provide following training for operation and maintenance staff for EOT Crane

- 6 working days training for four staff on operation of crane
 - 6 working days training for four staff for maintenance of the crane.
- Two sets training material shall be provided to the trainees.

DOCUMENTS TO BE PROVIDED

All documents shall be provided in English.

In the Bid

The PST contractor shall provide, for each overhead travelling crane:

a detailed technical note including a description of the equipment, main dimensions and total electrical power required,

- ☐ photographs or sketches of similar equipment with a list of references,
- ☐ general drawings substantiating the good installation of the equipment,
- ☐ references of the sub-PST contractor s,
- ☐ the various speeds for each of the movements,
- ☐ the standards and specifications that the main components used in the installation satisfy.

For Execution of Work

Prior to manufacture of equipment, the PST contractor shall send the following documents for approval:

- detailed dimensional drawing of the elements of the machine, and dimensions of the cabinet,
- ☐ general, detailed assembly drawings and drawings of mechanical parts,
- ☐ a note, indicating that the provisions in the civil work are compatible with the equipment offered,
- ☐ characteristics of the drum and the pulley block system,
- ☐ detailed calculation notes,
- ☐ references and characteristics of the main standard parts,
- ☐ detailed electrical diagram for troubleshooting including cable index,
- ☐ detailed electrical diagram for troubleshooting including cable index,
- ☐ electrical power required at each workstation, including switchboard equipment breakdown,
- ☐ list of basic spare parts to be kept in stock for repairs, during DLP,

- documentation, drawings, notes and references of sub-PST contractor s,
- installation and commissioning procedure,
- schedule of work and completion period.

At Completion of Work

The PST contractor shall provide the entire documentation, upto date:

- the general nomenclature of the supply including sub-PST contractor s,
- mechanical drawings and electrical diagrams required for maintenance and troubleshooting of the machine,
- illustrated lists of mechanical and electrical parts itemised in accordance with the diagrams and drawings mentioned above and including the addresses of the various PST contractor s,
- Two sets of maintenance and adjustment manual with summary of circuits and functions and among other information, a lubrication manual including location of lubrication points, type of lubricants, frequencies and quantities,
- Two sets of an operating manual including start up and user's instructions,
- complete documentation on motors,
- test reports or certificates for conformity of the equipment,
- list of recommended spare parts for two years requirements.

COMMISSIONING

After completion of work, the crane shall be commissioned and all the commissioning tests shall be jointly carried out by the PST contractor and The Engineer and recorded in the format given by the PST contractor and approved by The Engineer. All the equipment, tools & tackles and measuring instruments shall be arranged by the PST contractor . All consumables shall be arranged by The PST contractor.

Check List for EOT Cranes			
CLAUSE	S.N.	DESCRIPTION	OBSERVATION
General	1	Checking of Parameters as per Approved GTP	
	2	Checking of Dimensions as per Approved Drawings	
	3	Checking of Internal Test report	
	4	Checking of Calibration Certificate for equipment used in testing	
TECHNICAL SPECIFICATION EOT CRANES			
		Mechanical Parts	
Crane Bridge	1	Check the Bridge has two Double Girders of the Plate Box type	
	2	Check the Connection between the Crane Girder and End Carriages is made through High Strength Frictional Grip bolts with Space Washer	
	3	Check the Inner Faces of the Plate Joints Containing Space Washers must be given one Primer Coating of 60 Micron Coating thickness	
	4	Check the Crane Bridge is carried on end trolleys with double flanged solid casted wheels of Spheroid Graphite Impregnated material	
	5	Check the Minimum End Clearance on each side of the Long Travel wheels should be 10mm	
	6	Check the wheels is mounted inside the end carriage and can be conveniently removed if	

		required	
	7	Suitable jacking pads should be provided on each Carriage for jacking up the crane while changing the Track wheels	
	8	Check the end carriage is fitted with suitable safety stops to prevent the crane from falling more than 25mm in case of the breakage of track wheel, bogie or axle	
Trolley Frame and Hoist	1	Check the trolley frame is welded rolled steel section, designed to transmit the load to all the bridge rails without undue deflection	
	2	Check the opening of the trolley frame is such as to keep the ropes at a safe distance from any part of the trolley frame or equipment	
	3	Check the trolley is fitted with substantial safety stops to prevent the trolley from falling more than 22mm in the event of Breakage of Track wheel, Bogie or axle	
	4	Check the trolley frame is provided with rubber stops designed to absorb the Kinetic Energy in the event of braking fault	
Rails	1	Check the bridge rail is square/rectangular bar of EN8/ SN 52 material	
	2	Rail stops welded should be provided to prevent creep in Longitudal Direction	
Rail	1	Check the Rail Wheels is of Double flagged with Straight tread	

Wheels	2	Check the wheels is of spheroid Graphite Impregnated Cast Iron Material to have minimum hardness of 22 HRC	
	3	Check the wheels blocks is connected to End Carriage through Pin Connection and Circlip Locking	
Rope Drums	1	Check the Drum is flanged at both ends	
	2	Check the Rope Drum is with rope guide made of tough plastic offering smooth lead-in by means of hardened pressure rollers mounted on anti-friction bearings	
Wire Ropes	1	Check the wire rope is of steel core IWRC with tensile strength more than or equal to 1570N per sq mm	
Gearing	1	Check the Gearing is of Suitable case carburizing low carbon alloy steels according to relevant IS	
	2	Check the gears is of only Helical type except in Planetary gear boxes which can be spur type	
Gear Boxes	1	Check the Gear Boxes is made either of high quality pressure die cast aluminium alloy or of frey cast iron housing	
Rope Sheaves	1	Check the Rope Sheaves is of Cast/forged Steel	
	2	Check the equalizer sheave is mounted above the trolley floor and easily accessible and removable from the trolley floor level	
Bearings	1	Check Ball and Roller anti-friction bearings is of only makes like NBC, SKF, FAG, NORMA, NRB,	

		NTN and KOYO	
Lifting Hooks	1	Check the Lifting hooks is of Standard plain shank type trapezoidal section hooks as per relevant IS	
	2	Check the hooks is mounted on grease lubricated anti-friction thrust bearing and a protective skirt is fitted to prevent rotation of hook	
Buffer	1	Check the spring loaded or other suitable buffer is fitted on the four corners of the crane and also at the four end of the bridge girders	
	2	Check the buffer is rigidly bolted in place preferably along the center line of crane rail or trolley rail	
		Electrical Parts	
Latchable Isolating Switch	1	Check for the latchable isolating switch is provided for maintenance purpose and shall impede any movement of the EOT Crane when maintenance work is in progress	
Down Shop Leads	1	Check the Down Shop Leads is of enclosed type with Copper Conductors	
	2	Check the conductor system is compact in construction finger safe to IP-23	
	3	Check the Down Shop Leads Connection to power supply as per approved GTP	
	1	Check the Protection Index and shall be IP 54	

Switch Boards and Gear	2	For Protection of each Drives, motor against overloads adjustable Inverse time lag manually reset electro-magnetic, type relays shall be	
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		provided for each motor	
	3	Check for each motor feeder is protected with no volt trip device and short circuit, and with instantaneous trip current sensitive type single phasing cum phase reversal preventor	
	4	Check the electrical switch board shall be key locked	
	5	Check the door shall include a 3-position switch provided for no-load testing of control circuits and shall be connected to the cabinet via an earth braid	
Control Pendant	1	Check for the control pendant is sealed and Insulated to IP 65 and unbreakable	
	2	Check the Control Pendant is capable of moving along the EOT crane independently from movement direction of hook	
	3	Check the Control Pendant is suspended with a Stainless Steel Wire	
	4	Check the Control Pendant cover is made out of Nylon fiber	
Radio Remote Control	1	Check the Wireless control facility is provided which incorporate control of movement in all directions	
	2	Check the operations features like 1. Emergency Stop button 2. Emergency alarm button 3. Normal ON/OFF button	

		4. Low/High speed button 5. Directional movement control buttons 6. Radio/Pendant control selection buttons	
	3	Check the overall weight of remote control hand set (transmitter) not to exceed 0.5kgs	
	4	Check transmitter is provided with a shoulder belt and shall be IP65 enclosure	
	5	Check the range of operation is 40 meters minimum	
Contactors	1	Check Contactors is of AC 4 Class of Duty	
	2	Electrical life of Contactor is minimum of 200000 cycles of Operations	
Control Panel	1	Check the Clearance between cable tray and each component should be minimum 25mm	
	2	Check the outgoing terminals should be minimum 100mm above the gland plate	
	3	Check the control panel box and base plate is having Identification label bearing details of project, electrical drawing number along with revision number	
	4	Check the Control Circuit wiring is done through Copper Conductor in the panel	
Cabling	1	Check the Phase Control Wiring should be 1.5 sq mm Gray while neutral wiring is Black in color	
	2	Check the Power Wiring is minimum 2.5 sq mm size and R, Y, B color coded for R, Y, B phase	

	3	Check the proper Ferruling is done according to GTP	
Motors	1	Check the Ingress protection level of motors and shall be IP 55	
	2	Check the motor shall have the Insulation class B	
Lightning	1	Check that all the double girders EOT Cranes other than of Inspection bay is provided with high bay light fitting with metal halide of 400W	
	2	Check that a switch is provided for tubes on the walkway	
	3	Check that two number of sockets (1 single phase, 20 Amps and 1 three phase, 32 Amps) is provided on Crane Platform	
	4	Check each walk way is provided with 2 units of 2 Nos. 40W Fluorescent tubes	
Protection and Safety	1	Check that all metal parts shall be Earthed	
	2	Check all the Movements (Lifting, Forward/Reverse, traversing) is provided with the limiting Switches	
	3	Check the Lifting movement is fitted with: 1. An over travel switch cutting off the power circuit which may be reset from the crane walkway 2. A load limiter which cuts off the power supply to all movements except lowering 3. A buzzer to warn the persons working near the crane operating zone when crane is in working condition	

Finishing	1	Check external part and ancillary parts shall receive	
		a. Primer cum Finish paint	
		b. Hempel fast dry 45410/ Sigma Cover 350/ Intergrade 345 make	
		c. 2 No of coating is done	
		d. Total DFT is 125 Micron	
	2	Check all equipment shall be painted Golden Yellow (RAL 1004)	
	3	Check all friction parts must remain polished and coated to protect them from corrosion until equipment start-up	
	4	Check all the nut, bolts, washers etc is GI except otherwise specified in GTP	

ANNEXURE-A9**Cable Laying: GPS Survey and Method Statement.****1. General**

This Section covers GPS survey of Underground cable and guidelines for preparing method statement for cable laying activities under this contract and this section specifies the scope of work, documents preparations, and execution, of above activities within RSS premises and from GSS to RSS premises. This method statement shall be prepared by cable manufacturer in line with these guidelines.

2. Details of Sections

- 2.1. GPS Survey of underground cable.
- 2.2. Guidelines for preparing method statement of cable laying.

3. Scope of Work

- 3.1. GPS Survey of underground cable.

The PST contractor will execute the work i.e. GPR Survey of Underground Cables of BSTP.

The work may be required to be carried out during power block in non-revenue hours.

The scope of work includes the following:

- (a) The work shall be carried out as per Contract, Special conditions of Contract and other terms & conditions given in the tender document.
- (b) PST contractor shall supply equipment of one of the following make – SPECTRA/SOUTH/ASHTECH/TRIMBLE/LEICA. Product of any other reputed GPS equipment manufacturer meeting given specifications shall be considered for supplying, however, in this case detailed technical brochure of equipment shall be submitted by the PST contractor to engineer-in-charge for approval. The equipment shall be supplied only after approval of engineer-in-charge.

3.1.1. The work shall be carried out by PST contractor as per following scope of work:

- 3.1.1.1.** All required manpower, DGPS survey, GPR equipment with different Frequency Antenna as required, Total Station Equipment, Induction Cable Locator shall arranged by the PST contractor. Other necessary Activities as leveling of surface (if required for carrying out survey), necessary permission from local civic authorities to produce the desired output will be in the scope of PST contractor, BSTP will help in this regards.
- 3.1.1.2.** The work shall be carried out in Bangalore as per direction of engineer in-charge.
- 3.1.1.3.** Before start of utilities detection survey PST contractor will have to submit the Execution Plan and Project schedule etc to engineer in charge.
- 3.1.1.4.** The survey shall be carried out for collection of information of utilities up to 5m depth on 5m wide corridor. The utility corridor of 5 meter will be based on field survey input. All utilities (both metallic and non-metallic) in the corridor need to be surveyed and scanned.
- 3.1.1.5.** The GPR survey to be done at intervals of 10 meter for straight run of cable and with close intervals of 2 meter at road crossings, location of SVL, junctions, other utilities (Water, Gas Pipeline & Electric Cable etc.). Crossing/parallel run or bent location and at new intermediate utilities appears.
- 3.1.1.6.** The survey should be conducted with adequate advanced technologies total station, DGPS, etc), in such a manner that all types of utilities, sewer line, cable/duct etc are identified. In case of any other methodology / technology is proposed by the PST contractor , the same may be agreed by employer provided that end results are same. However for any such changes approval of Engineer in-charge shall be obtained by the PST contractor after giving all technical details of the methodology / technology proposed to be adopted.
- 3.1.1.7.** Coordinate system (Universal Mercator system-UTM) provided, should allow superimposition on any standard mapping environment and platform like Google

Earth.

- 3.1.1.8. Undulations in land surface during utility scan to be taken care off.
- 3.1.1.9. Accuracy of utility detected for vertical and horizontal should not be more than 50 cm.
- 3.1.1.10. The validation of the report shall be carried out in presence of Engineer in- charge at one or more location in each line. The locations shall be provided by engineer in-charge randomly and joint report shall be prepared. For such locations, any work such as digging of earth as required shall be done by PST contractor without any extra cost to the employer. In case during validation of the location of cable it is found that position of cable is at distances more than given tolerance band, entire survey shall be carried out again by the PST contractor until desired accuracy is achieved.
- 3.1.1.11. The survey should also pick up all surface projections of utilities such as manhole valves, chambers, junction box, fire hydrants etc. falling in the corridor.
- 3.1.1.12. If the utility corridor falls on both foot path and on carriage way, GPR scanning to be done on both foot path and carriage way and if there are any obstruction in the survey corridor, the readings to be taken before and after the obstruction and also whatever readings possible in between.
- 3.1.2. **The drawings/maps should have following notable features:**
Horizontal/Vertical scale to be selected suitably to show the utilities clear,readable and legible. Relative depth of utility shall be with respect to chart datum (MSL) or any known permanent bench mark level established by Survey of India in the near vicinity. Further depth of the cables should also to be provided with respect to the ground surface.
- 3.1.2.2. The reference points to be created (and to be shown in drawings) from where relative location of cables can be marked and will be associated with various utilities like manhole valves, fire hydrants, chambers, and junction boxes etc for better understanding for field team. In the drawings, distances of these utilities from cable also to be shown.
- 3.1.2.3. Depth below ground shall be annotated at each measured change and at significant change of depth (more than 50 cm change) & shall be indicated in the diagrams/maps and chapter.
- 3.1.2.4. The survey and record making shall be carried out as per guidelines and technology mentioned above. In case of any other methodology / technology is proposed by the PST contractor , the same may be agreed by the employer provided that end results are same. However for any such changes approval of

Engineer in-charge shall be obtained by the PST contractor after giving all technical details of the methodology / technology proposed to be adopted.

- 3.1.2.5. PST contractor shall submit preliminary drawing to engineer in-charge during execution of work.
- 3.1.2.6. After the completion of work, as built drawings shall be furnished incorporating all the suggestions given by engineer in-charge. In the drawing at one end, title block shall be provided. Legends of symbols used shall also be provided in the drawing and drawings/maps shall be published by PST contractor in mutually agreed format only. The soft and hard copies of as built drawings (in pdf & AutoCAD both) shall be given by the PST contractor .

ANNEXURE-A10**Fixed type Digital Fault recording system (DFRS)**

1. Detailed Description of the Equipment & Its application in BSTP: DFRS
The Supply, design, manufacturing, installation, testing and commissioning of complete digital fault recorder at 220 kV, 33 kV and 25 kV bus of RSS in accordance of IEC/EN/IS standards, it shall be multi-functional and must complies with communication protocol IEC 61850 (MMS, GOOSE messaging, and sample value).

As wave recordings of different signals shall be done at all voltage level in each RSS, which shall be complied at one centralized sever for monitoring at each RSS level and similarly, data from all RSSs shall be complied at one centralized server at OCC / or one particular RSS with same features as of centralized unit for monitoring at RSS.

2. Governing Specifications

Digital fault recorder system shall conform to the latest standard as given below or specified along with the equipment in the specification.

In case of any conflict between specifications & the standards, the instructions / decision of the Engineer' or Employer's authorized representative shall be binding.

3. Technical and Installation Requirement

- 3.1 Description

The Digital Fault recorder shall be panel mountable; the PST contractor shall mount the DFR in respective panels for 220 kV, 33kV and 25kV as per requirement.

Necessary

interface with panel OEM shall be done by PST contractor during design stage.

It shall be fully featured digital fault recorder having latest technology. It shall be a distributed multi- functional data acquisition device that continuously records all waveform signals at a sampling rate of 1,024 Sample / Cycle for monitoring, protecting, operating, power quality, synchro phasors and load profiles. It shall provide a powerful platform for acquisition, analysis and report of data from power system substations.

Detailed features required in Digital fault Recorder system are as follows:

- a. This system shall perform following functions:
 - i. Digital Fault Recorder (DFR)
 - ii. Phasor Measurement Unit (PMU)
 - iii. Power Quality Monitoring (PQM)
 - iv. Sequence of Event Recording (SER)
 - v. Dynamic System Monitoring (DSM)
 - vi. Impedance based Fault Location (IbFL)
- b. It shall be modular and panel mountable type.
- c. Inputs shall be taken from all bays at 66 kV voltage level, Incomer bays and outgoing bays for network at 33 kV voltage level, and all bays at 25 kV voltage.
- d. Centralized server shall be provided at each RSS and one centralized server for all RSSs shall be provided.
- e. All units shall communicate at IEC 61850 protocol with SAS/RSS SCADA unit.
- f. It shall allow interface with any web-enabled device using most web servers.
- g. It shall have continuous waveforms recordings at high-speed i.e. 1024 samples / cycles with higher bit converter for superior accuracy.
- h. The system shall record following data continuously at high resolution:
 - i. Phasor angle between voltage and current.
 - ii. Complies with IEC 61000-4-30, voltage sags (dips), swells, interruptions, and rapid voltage change.
 - iii. Waveforms of all inputs.
 - iv. Complies with IEC 61000-4-7, total harmonics distortion (THD), crest factor, K factor and up-to 100th harmonics.
- i. It shall have minimum 3 USB, 2 Serial and 1 LAN communication ports.
- j. It shall have extensive charts capabilities not limited to trend chart, phasor chart, spectrum chart, cyclic histogram chart, event chart, and etc.
- k. It shall have 7-inch-high resolution touch LCD display HMI.

- l. Hardware shall be robust.
- m. Sever computer shall consist of latest processor at the time of ordering but not less than Intel Xeon or Core i7 quad-core CPU, 32 GB DDR4 type, Industrial-grade SLC SSDs in 256 GB capacities; industrial-grade multilevel cell (iMLC) SSDs in 480 GB; and nonindustrial MLC SSDs in 2 TB (4 TB maximum storage), Second load-sharing, high-voltage, and hot-swappable ac/dc power supply, with Windows® 10 IoT Enterprise LTSC and Windows Server® 2016 Standard, or Windows Server® 2012 R2 Standard. Server computer shall consist of 23inch FHD display monitor.
- n. All cards shall have conformal coating of industrial grade conforming to minimum class 3C2.

3.2 Server Software

Following are minimum features required: -

The software shall have capability for Integration of multiple digital fault recorder and Minimum three concurrent user from one central SCADA server can be associated. The software shall have feature for assigning permissions to groups and users. Different location of measurements, trends, waveform, & graphs can be plotted on single page for analysis.

The software shall have feature for data analysis using Multi-site investigation, Trend Chart, Phasors, Grid Chart, Summary Chart, Spectrum Chart, Statistics Chart, Event Chart, Scatter Event Chart, Scatter parameters chart, Cyclic Histogram.

There shall be live monitoring of Trends, Phasors, & Values. The data can be imported in the different file format like Excel, CSV, Word in a standard template

3.3 Technical Specifications

S. no.	Item	Requirement
1.	Measurement Channels	Device should measure 16 Voltage or 16 Current or combination of Voltage & Current.

2.	Measurement Standards	IEC61000-4-30 Ed. 3 (2015) Class A
		IEC 62586-2 Ed. 2 (2017)
3.	Measurement Range Voltage	
i.	Full range scale	500V/1,500V/8000V
ii.	Peak Voltage	8000V AC
iii.	Accuracy	0.1%
4.	Measurement Range Current	
i.	Nominal	5A AC
ii.	Peak Current	50 A AC
iii.	Accuracy	0.1%
5.	Measurement Range Frequency	
i.	Fundamental Frequency	50 Hz
ii.	Frequency Resolution	As per manufacture
iii.	Accuracy	As per manufacture

6.	Measures parameters	Frequency, Active power, Apparent power, Reactive Power, Power Factor, Vthd [amplitude & percentage], Ithd [amplitude & percentage], TDD, Phase Angle, Positive Sequence, Negative Sequence, Zero Sequence, Pst, Plt, Voltage Waveforms, Current Waveforms, Harmonic Voltage waveforms, Harmonic Current waveforms.
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7.	Harmonic range	Up-to 100 th level
8.	Inter harmonics Range	Yes
9.	Sampling frequency	1024 / cycle for all channel simultaneously.
10.	Analog to digital converter	24 bit or higher
11.	Recoding data	
i.	Recording Norms	Continuous recording with or without threshold and triggering setting (waveform recording)
ii.	Recording duration	Cycle by cycle recoding of all channel for 1 year
12.	Memory storage	32 GB or higher
13.	Data storage capacity	One-year data of all measured parameters.
14.	Time synchronization	All equipment shall sync with master clock
i.	GPS	
ii.	IRIG B	
iii.	NTP	
iv.	Internal Real time clock	

15.	Communication	Optical fiber, LAN (IP based)
16.	Communication protocol	IEC 61850
17.	SFP Ports	
18.	Serial Ports	Min 2 nos

19.	USB ports	Min 3 Nos
20.	PPS	
21.	Power Supply	110 V DC; Auxiliary 240 V AC
22.	Device configuration	Web browser based through IP address.
23.	Human Machine Interface (HMI)	7" high resolution LCD, additional web server for local and remote real time monitoring and historical data analysis and control
24.	Environmental Conditions	As per GS
25.	Mechanical Dimensions	As per manufactures
26.	Software (Parameters Available for Analysis)	Easy for report creation, Different location measurements trends should be plotted on single graph.
i.	RMS Voltage	
ii.	RMS Current	
iii.	Active Power	
iv.	Apparent power	
v.	Reactive Power	
vi.	Power Factor	True, Displacement PF
vii.	Active Energy	Import, Export
viii.	Apparent Energy	Import

ix.	Reactive Energy	Import, Export
x.	Harmonics Voltage	Up-to 100 th level, THD, Amplitude, Percentage, Angle, Waveform
xi.	Harmonics Current	Up-to 100 th level, THD, Amplitude, Percentage, Angle, Waveform
xii.	Inter harmonics	Yes
xiii.	Flicker	Pst 10 min, Plt 2 hours,
xiv.	Unbalance	Negative Sequence, Zero Sequence
xv.	Transient	
xvi.	Waveform	All channels & for all the recording period should be recorded. Irrespective of event trigger condition.
xvii.	Events as per EN50160	Customized thresholds should be available. Dip, Swell, Short & long Interruption, Rapid Voltage Change, Frequency Variation, Harmonic Deviation,

ANNEXURE-A-11

OPTICAL FIBRE CABLE

1. General

This specification covers the broad guidelines for design and construction requirements for Single Mode Optical Fiber Cables for this tender.

The PST contractor shall be responsible for ensuring adherence to relevant specifications wherever applicable, sizing, procurement, installation, wiring and testing of OFC in each RSS required for the protections and control of power system.

2. MANUFACTURING, PHYSICAL AND GENERAL PERFORMANCE REQUIREMENTS

2.1. General

2.1.1. The cable shall have continuous operating life of at least 30 years and for Telecom cables it should be at least 25 Years.

2.1.2. The cable shall be to latest IRS specifications or other international standard for railway signaling cables. The PST contractor shall submit the standards and specifications to which the proposed cable comply. Optical fibre cables shall be laid in HDPE pipe.

2.1.3. HDPE pipe for protection of optical fibre cables shall be solid, rugged, minimum 40mm diameter, permanently lubricated and suitable for air blowing of optical fibre cable. HDPE pipe shall be to latest TEC specifications.

2.1.4. The cable shall be armoured type and shall be able to withstand rain and ultraviolet ray exposure. The cable insulation shall be moisture & heat resistant and be able to withstand temperature up to 70°C.

2.1.5. The cables shall be resistant to any kind of corrosion due to soil & environmental conditions and shall be suitable for use and also be immune from degradation under the following atmospheric impurities and environmental conditions:

- (a) Total immersion in water, acidic solutions with low concentration, salty media, etc.
- (b) Exposure to toxic materials, dirt, dust, grease, oil hazardous gases, etc.
- (c) Exposed to atmospheric conditions including indirect sunlight

2.1.6. The outdoor single mode optical fibre cable shall have minimum fibre count of 6 fibres.

2.1.7. Optical Fiber Cables shall be constructed with Dispersion Unshifted Single Mode Optical Fibers, with a matched cladding.

2.1.8. Matched clad fibers feature a dual UV curable acrylate coating system.

- 2.1.9. The coating is easily strippable using mechanical methods.
- 2.1.10. Each fiber is proof-tested to 100kpsi, so it will survive installation loads and associated long term residual stresses, even under extreme environmental conditions.
- 2.1.11. The optical, dimensional, and mechanical properties are measured for compliance to Industry Specifications (IEC, IS etc.).
- 2.1.12. Fusion splicing shall be done.
- 2.1.13. Single Mode Fibers shall be manufactured to meet low polarization mode dispersion (PMD) specifications.
- 2.1.14. The Employer or his Engineer shall have free access to the works of the manufacturer and shall be given facilities by the manufacturer to inspect the manufacturing of the cable during any stage of manufacture. He shall have right to reject the manufacture in whole or part of any work or material that does not conform to the terms of this specification or and may order the same to be removed/ replaced or altered at the expense of the manufacturer.
- 2.1.15. In case of no relevant test certificates being available, tests shall be carried out by the manufacturer as those laid down with relevant specification but this shall not preclude any test desired by the Employer's Engineer to determine the quality of the cable. The PST contractor shall satisfy the Employer's Engineer regarding the quality of cable supplied by him by production of a certificate from a recognized testing laboratory or otherwise that the materials used and the cable itself meets with the required standards and meet with all the testing requirements of relevant specifications.

2.2. Manufacturing process:

- 2.2.1. Optical fibers shall be placed inside a loose buffer tube.
- 2.2.2. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel can be readily removed with conventional nontoxic solvents.
- 2.2.3. Buffer tubes containing fibers shall be color-coded with distinct and recognizable colors.
- 2.2.4. All buffer tubes shall have a filling compound to provide water penetration resistance and to cushion the fibers during installation and operation.
- 2.2.5. The buffer tubes shall not kink when a 360° loop is freely bent to a diameter of 10Dmm, where D is the diameter of the tube.
- 2.2.6. The fibers are colored with ultraviolet (UV) curable inks.
- 2.2.7. The fibers do not adhere to the inside of the buffer tube.

- 2.2.8. The cable shall have central anti-bucking member consists of a dielectric, fibre reinforced plastic (FRP) rod.
- 2.2.9. Water-blocking technology [Dry binder threads are impregnated with the Super Absorbent Polymers (SAP) / water blocking tape (non-nutritive to fungus, electrically non-conductive, and homogenous) / glass fibre yarn reinforcement] shall be provided over buffer tube to impede migration of water through the cable core.
- 2.2.10. The cable core shall be stranded evenly around by High tensile strength dielectric yarns.
- 2.2.11. The cable shall have two ripcords and low smoke zero halogen fire resistant inner sheath.
- 2.2.12. Water-blocking technology [glass fibre yarn reinforcement] shall be provided over inner sheath.
- 2.2.13. The cable shall be corrugated steel tape armored type, and plastic coated on both sides for corrosion resistance.
- 2.2.14. The outer jacket of the cables shall be of a black High-Density Polyethylene (HDPE) extruded with low smoke zero halogen and UV resistant.
- 2.2.15. Cable Sheath Marking: All cables have sequential length markings along the cable sheath. The cable is marked in white print every meter. The height of the marking is approximately 2.5mm. "BSTP - Optical Fiber Cable - GSS name **to RSS nameMeter**".

2.3. FIBER SPECIFICATIONS

The dispersion unshifted single mode fiber utilized in the cable is made to the following specifications:

S. No.	Item Description	Required
1.	Typical Core Diameter	8.3 μm
2.	Cladding Diameter	125.0 + 1.00 μm
3.	Core to Cladding offset	$\leq 8 \mu\text{m}$
4.	Cladding Non-circularity	$\leq 1\% \{1-(\text{min Cladding dia}/\text{max. cladding})\} \times 100$
5.	Coating Diameter	245 $\pm$ 10 μm
6.	Colored Fiber Diameter	Nominal 250 μm

7.	Cable external diameter	13.5 mm	
8.	Cut off Wavelength	>1260 nm	
9.	Mode-field Diameter	9.30 ± 0.50 µm at 1310 nm 10.50 ± 1.00 µm at 1550 nm	
10.	Cabled fibre attenuation	Max. Attenuation	Avg. Attenuation

		(dB/Km)	(dB/Km)
	Wavelength	1310 nm	0.38
		1550 nm	0.25
11.	Attenuation uniformity	No point discontinuity greater than 0.1 dB at either 1310 nm or 1550 nm.	
12.	Attenuation at Water Peak	$1383 \pm 3\text{nm} < 2.1\text{dB/km}$	
13.	Maximum total dispersion	$1285 \text{ } 1330\text{nm}: \leq 3.2\text{ps} / (\text{nm} * \text{km})$ $1550\text{nm}: \leq 18.0\text{ps} / (\text{nm} * \text{km})$	
14.	Zero Dispersion Wavelength	$1301.5\text{nm} \leq \text{ZDW} \leq 1321.5\text{nm}$	
15.	Zero Dispersion Slope	$\leq 0.092\text{ps} / (\text{nm}^2 * \text{km})$	
16.	Fiber Polarization Mode Dispersion (PMD)	$\leq 0.5\text{ps} / \sqrt{\text{km}}$	
17.	Fiber Curl	$\geq 4.0\text{m}$ radius of curvature	
18.	Cable weight	180-240 Kg / Km	
19.	Operating temperature range	-20°C to $+60^\circ\text{C}$	
20.	Storage Range	-20°C to $+70^\circ\text{C}$	

2.4. Tests:

2.4.1. contractor The cable shall be tested as per relevant latest IEC / IS standard. PST shall prepare and submit list of all type tests, routine tests, and special tests as per standard to Employer for review.

2.4.2. Test results and certificates shall be submitted for review to the Employer's Engineer.

In case of no relevant test certificates being available, tests shall be carried out by the manufacturer as those laid down with relevant specification, but this shall not preclude any test desired by the Employer's Engineer to determine the quality of the cable.