



KHATUN ABAD GAS POWER PLANT (MGT70)
230KV SUBSTATION
TECHNICAL SPECIFICATION



230 kV
Substation
AIS



KHATUN ABAD GAS POWER PLANT (MGT70) 230KV SUBSTATION TECHNICAL SPECIFICATION



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1. General

The project covered under this specification is design, procurement, factory acceptance tests, installation, site acceptance tests and commissioning of 230kV substation including all outdoor and indoor equipment & auxiliaries and civil works (substation work and buildings).

The complete substation will be operated, controlled and supervised from central control, considering all necessary signals & controlling between power plant & substation.

Requirements & Instructions issued by TAVANIR / IGMC (Iran Grid Management Company) at contract signature time, for safe & secure operation of substation & power plant (according to scope of work), also IEC standard will be observed in design & construction of the installation.

2. Equipment and Systems Description

2.1 Power Circuit Breakers

Circuit breaker operation will be essentially re-strike free.

Circuit breaker will be capable of single phase (where specified) and three phase tripping and high-speed auto reclosing duty according to duty cycle O - 0.3 Sec - CO 3min - CO at its rated interrupting capacity.

Circuit breaker will be complete with operating mechanism, Electrical linkage and wiring between poles, mechanism, and all other necessary accessories. Circuit breaker will be capable of interrupting at maximum design voltage, any kind of load, at any power factor with any percentage of magnitude (from zero up to 100%) of continuous current rating.

Circuit breaker will be capable of completely interrupting 50 Hz, single and three phase faults at rated voltage of any type from zero to 100% of the specified interrupting rating and specified time.

Two independent trip coils will be provided for each actuating mechanism.

Spring and hydraulic operating mechanisms only will be considered.

The relation between current and time will be in accordance with the formula: $I^2.t = \text{constant}$. Circuit breaker will be electrically and mechanically trip-free and it will be provided with an anti-pumping device.

Where applicable, depending on the type offered, each pole of the circuit breaker will be equipped with:

- Emergency vent or pressure relief valve for discharging gases released during circuit interruption. The vent will be rain and dust proof.
- Suitable eye bolts, lugs etc. for lifting the essential parts.

The frames or bases will be fabricated of hot-dipped galvanized structural steel. Bolts, nuts, washers, steel shapes, plates, etc. will be galvanized in accordance requirements of ISO 1461 or equivalent standards this structure will be supplied by CB supplier.



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The main contacts will be designed to have adequate thermal and current carrying capacity for the duty specified. The contacts will have long life so that frequent replacement will be unnecessary.

The contacts will be equipped with modern and effective arc extinguishing devices and will be designed for ease of replacement.

Main contacts will be the first to open and the last to close so that there will be little contact burning and wear.

Arcing contacts, will be the first to close and the last to open and will be easily accessible for inspection and replacement.

Each unit assembly will be provided with two grounding pads located on opposite sides.

The entire circuit breaker assembly will be designed and constructed so as to safely withstand the short circuit and operating stresses which may be imposed upon it.

The mounting structures for individual pole units will have their bases at the same elevation.

The circuit breaker will be equipped with porcelain/silicon rubber insulators, enclosures and supports, as appropriate. All insulators enclosures and supports of like ratings will be interchangeable.

All insulator (or hollow insulator) and enclosures will be so designed that there will be no stressing of any parts due to temperature changes and adequate means will be provided to accommodate the expansion of current carrying parts and conductors.

All parts will be free from objectionable radio interference and free from external and internal corona.

Circuit breaker units will be designed to be lifted by mechanical devices so that insulators are not under stress during lifting.

External parts of circuit breaker will be of insulator and suitable for type of pollution specified.

All the auxiliaries for the circuit breaker as heaters, motors, lights, etc., will be suitable for operation at 50 Hz, and specified AC/DC supply. The manufacturer will furnish one MCB for each individual load circuit as appropriate.

All AC auxiliaries will operate satisfactorily in the range of 85 % to 110% of the rated voltage and 90% to 105% of the rated frequency.

Circuit breaker will be designed so as to ensure that the rate of gas leakage is maintained at an absolute minimum and that the moisture content of the SF₆ gas is maintained sufficiently low so as to avoid condensation forming on the internal insulating surfaces of the circuit breaker.

Gas density in the SF₆ circuit breaker will at all times be not less than the density which is required for dielectric voltage.

Proper gas density monitoring equipment (dial type is preferred) will be provided with minimum two stage, first for refill and the second step for blocking or emergency trip of C.B., with remote indication facilities.



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Sufficient SF6 gas will be provided to fill the circuit breakers supplied plus an additional 20 percent of the total quantity for future usage.

A lock-out device, with provision for remote indication will be incorporated in each circuit breaker to prevent operation whenever the SF6 gas pressure/density in the breaker is less than required for satisfactory operation at the specified rating.

The SF6 gas will comply with IEC 376 and be suitable in all respects for use in the switchgear when it is operated under conditions specified.

Filters, drains, gauges, valves, piping, moisture control equipment etc., will be provided.

The gas system will be of the type in which the gas is reused after filtering and reconditioning.

Provisions will be made to ensure that the SF6 gas remains in its gaseous state when the circuit breaker operating at an ambient temperature as specified.

The circuit breaker will have a well proved sealing system and the leakage of gas will be less than 1% per year under all operating conditions.

The circuit breaker will be mechanically dimensioned for stresses due to ice load, wind load; short circuit forces, tensile forces in connections considered as acting in the most unfavorable direction, Inner pressure due to SF6 gas and earthquake. The CB will function correctly under the combination of action of the mentioned forces.

The noise made by the circuit breaker during opening and closing under all specified conditions will be kept to a minimum.

The circuit breakers will be capable of parallel tripping when installed in the 1.5 breaker configuration without delaying the tripping of either breaker.

2.1.1 Operating Mechanism

The operating mechanism will be equipped with suitable controls to permit remote operation and local electrical opening and closing of the breaker.

Manual closing will be possible for maintenance works.

The operating mechanism will be provided with a counter for counting at least 9999 CO-cycles.

The operating mechanism and the circuit breaker poles will be provided with mechanical position indicator. The indicator will be mechanically operated and be labeled open and closed with black color on the green and red color basis respectively.

The operating mechanism will be provided with two independent trip coils per pole, and all necessary circuits, each circuit will be capable of operating normally with or without any voltage on the other circuit. These trip coils will not have common flux parts and will not be connected in series and will operate simultaneously and will be arranged such that a failure of either coil will not jeopardize the operation of the other coil.

Each trip coil will be suitable for supervision by a lamp or relay which are in series with the trip coils.



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The trip coils will have a correct function between 70% and 110% of rated voltage and closing coil between 85% and 110% of specified AC voltage.

Manual 3 phase closing and tripping and also 1 phase tripping will be possible for maintenance workers by the central mechanisms.

Manual tripping will be possible even in the absence of supply voltage, for emergency cases, unless the breaker is locked out.

All circuit breakers will be provided with means to prevent contact pumping while the closing circuit remains energized. This arrangement will not involve paralleling of the trip and close circuits.

An Emergency trip device, suitable for operation in event of failure of electrical supplies will be provided at each circuit breaker. The device will be distinctively labeled and protected against inadvertent operation.

Provisions will be made for remote indication of the following operations through a pair of NC (Normally close) and NO (Normally open) voltage free contacts:

- Circuit breaker opened
- Circuit breaker closed
- Circuit breaker tripped
- Failure to complete closing or opening operation for each phase.

The test voltage for the operating mechanism will be at least 2000 V, 50 HZ, 1 minute.

All the breakers will be free to open immediately after the trip coil is energized. On simultaneous receipt of close and trip signals, the trip signal will be predominant.

Where operating mechanisms are provided for each phase of the circuit breaker they will be electrically interconnected so as to ensure simultaneous operation of each phase when operating on three phase duty.

Motors will be protected against switching over voltages caused by operating mechanism auxiliaries. The voltage amplitude will not exceed 50% of the rms. value of the insulation level.

The mechanism will not be damaged by remaining operating impulses.

The motor and other parts will be so designed, that the mechanism can, without sustaining damage, perform at least 10 consecutive closing and opening breaker operations at rated voltage.

The mechanism will be provided with a heater for protection against dampness and condensation and also additional heater which will be controlled by an adjustable thermostat placed inside the mechanism.

It will be possible to switch the circuit breaker using the operating mechanism into the open or closed positions electrically by close and trip coils either remote operation or locally by pushbuttons or similar devices working directly in the mechanism. In addition, another push button working with and without auxiliary voltage will be provided for emergency trip. This pushbutton will be accessible without opening the case of the operating mechanism but be



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protected with covers etc. To prevent unauthorized operation, it will be labeled emergency trip.

The operating mechanism will be so designed that the close releases is blocked during an existing trip impulse. The mechanism will be so designed that the trip impulse has precedence over the close impulse when the circuit breaker is in a position to transfer the current (either by touch of the contact or an arc between them.)

The operating mechanism will be reliable and durable so as to function faultlessly regardless of the frequency of operation.

Circuit breaker mechanisms and all parts requiring lubrication will be housed in enclosures weather proof, IP54.

Mechanism housing will have hinged inspection doors provided with necessary fittings for pad locking when closed. The doors will be arranged to provide complete access for maintenance and removal of all equipment.

The operating mechanism will be provided with suitable hooks for lifting it.

The operating mechanism will be within easy reach of a man standing by the CB, otherwise ladders conveniently located will be provided.

2.1.2 Control cabinet

The control cabinet will be equipped with hinged doors and stops, IP54 protection degree, weather proof and provided with a continuous rubber gasket. A secure locking handle will be supplied to use doors closed.

The control cabinet will be equipped with the following as a minimum:

- A local/remote selector switch
- A pair of pushbuttons or one rotary switch for local 3ph open/close operation and other pushbutton or switch for opening of individual poles during maintenance
- Thermostatically controlled space heater, 230VAC and relevant MCB
- MCB for control circuits
- Internal light with door switch
- An operation counter
- Anti-pumping relay
- A grounding connector with suitable size and copper grounding bar with enough rectangular section and necessary holes for earthing of the cable shields
- Suitable labels will be provided for each device inside the cabinet
- A set of wires, wire ducts, terminal blocks, ferrules, fuse links, etc.
- Motor(s) with pertinent equipment's (if applicable)
- 2pole DC, or 3pole AC MCB with adjustable thermal capacity for feeding of the motor



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2.1.3 Terminal blocks and wiring

The mechanism will be provided with a sufficient number of terminal blocks. The blocks will be provided with provision for disconnection but this will only be possible with tools.

It will be possible to perform disconnection without disconnecting the leads. The block will be marked with clear and resistant signs. All control wire will be of an insulation class not less than 600 volts. The wiring will be adequately supported by suitable spacers.

Terminal blocks will be complete with washer, nuts and lock nuts and long enough for connecting two conductors to one screw connection.

Marking strips will be fastened by screw and correspond to wire numbers on the wiring diagrams. 10% spare marking strips will be provided.

AC circuit terminals will be fitted with nonflammable transparent plastic covers to prevent contact with any live parts. They will have warning labels mounted there on.

They will also be separated from DC circuits.

The main mechanism housing will have enough space for cables which will terminate on the terminal blocks.

TABLE 1: RATINGS AND CHARACTERISTICS OF CIRCUIT BREAKER

Item	Description	Technical Particulars	Unit
1	Type designation for breaker	SF6	
2	Applicable standard	IEC 62271-100	
3	Class	Outdoor	
4	Number of pole	3	
5	Rated frequency	50	Hz
6	Rated voltage	245	kV
8	Whether single pole or 3-pole operation	As per SLD	
9	Min. creepage distance	7595	mm
10	Rated lightning impulse withstand voltage: To earth across open circuit breaker	At IEC condition 1050 1050	kV
11	Rated 1 min. power frequency withstand voltage: To earth across open circuit breaker	At IEC condition 460 530	kV
12	Rated normal current at site condition	As per SLD	A
13	Rated short time withstand current	As per SLD	kA
14	Rated line charging breaking current	125	A
15	Rated cable charging breaking current	250	A
16	Rated short circuit making current	2.5×Isc	kA



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17	First pole to clear factor	1.3	
18	Rated operating sequence	O-0.3S-CO-3min-CO	
19	Rated out of phase breaking current	12.5	kA
20	Minimum number of breaking operations before any Inspections or maintenances are required	2000	
21	Operating mechanism: Type of mechanism Motor voltage Rated control voltage Heater voltage for motor operation mechanism Number and type of auxiliary switches(Total),(free) Degree of protection of operating mechanism	Spring 110VDC 110VDC 220VAC (19NO+19NC),(15NO+16NC) IP 55	

2.2 Disconnectors and Earthing Switches

Disconnecting and earthing switches will be complete with insulators, terminal connectors, operation/ Earthing mechanism, control-gear and all other necessary parts for complete and safe operation.

Disconnecting and earthing switches will be designed to carry the specified rated current continuously without exceeding temperature rise as outlined in the relevant IEC.

Disconnecting switches will be three phase gang operated or single phase operated with poles operating simultaneously. They will be designed for motor operation and they will also be equipped with provision of manual operation.

The minimum total length of the air-gap between terminals of one pole and distance between phases when the disconnecting switch is in open position will be designed to withstand the voltage levels as specified.

Disconnecting and earthing switches will be capable of withstanding the mechanical and thermal effects due to passing the rated short time current through them without any kind of damage or burning the contacts.

Disconnecting switches current carrying parts will be capable of carrying the full load current of the circuit but will not be required to break or make currents other than the charging current of open busbars and connected equipment, charging current of unloaded lines or load current shared by parallel circuits. The speed of operation will be such to interrupt the corresponding current.

Service conditions require that the disconnecting switches remain alive and in service without any operation and maintenance for period of at least 3 years. Therefore the contacts will be expected to carry the rated load and short circuit currents without overheating and after such period, the minimum torque of 150 N required to open the disconnecting switch by operating handle will be within capability of one man.



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The entire operating mechanism will be so designed that all three blades are in control throughout the operation cycle, therefore after the final adjustment it will be impossible for any individual part of the mechanism to be displaced to allow improper function of the switch.

The disconnecting and earthing switch contacts design will be such to maintain pressure and be suitable for further operation after carrying rated current.

A suitable flexible braid type connector will be provided on the hinge end of the earthing blade with a clamp connector for connection to substation ground bus.

The performance of switches will not be affected by pollution on external insulation, therefore suitable design will be considered for the types of insulators and hot washing capabilities.

All disconnecting and earthing switch parts will be of corrosion resistance material with respect to all weather conditions and all types of atmospheric pollution which can occur. Steel parts in disconnecting switch and operating mechanisms will be hot - dip galvanized which will be carried out in accordance with ISO 1461.

Blades and fittings of the switches will be designed to reduce corona discharge to minimum and uniform distribution of voltage gradient.

Disconnecting and earthing switches will be able to close and open whilst subjected to their rated terminal load plus wind loads acting on the equipment itself, increased by presence of ice coating.

Disconnecting and earthing switches including their operating mechanisms, will be so designed that they cannot come out of their open or closed positions by gravity, wind pressure, vibrations, short circuit and etc.

2.2.1 Operating mechanics

Disconnecting and earthing switches will be operated either by one mechanism for three-phase gang operated or separated mechanisms for single phase operated.

The operating mechanism will be provided with a lock device for choice between manual or motor operation.

The open and closed positions of the disconnecting and earthing switches will be indicated mechanically on the operating mechanism.

The complete assembly of the mechanism will be enclosed in a weather-proof housings which will provide easy access to all parts. The housings will have at least protective class IP54. Suitable thermostatically controlled heaters will be provided to prevent accumulation of moisture in the housings. The housings will also be equipped with inner light and door switch.

Motor operated disconnecting and earthing switches will be provided with local/remote selector switch and open / neutral/close control switches.



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The earthing switch and its associated disconnecting switch will be interlocked so that neither can be operated if the other one is closed and electro-mechanics & mechanical interlocks will be with good reliability.

Disconnecting and earthing switches operating mechanism will be designed to permit locking both in the open and closed positions.

To eliminate the risk of mal-operation, the operating mechanisms of disconnecting and earthing switches will be interlocked relative to each other to make sure that the earthing switch can be operated only when the disconnecting switch is open and feeder is de-energized and vice versa.

In order to ensure safe access of operation and maintenance personal to equipment and also normal system operation and predetermined sequential switching in the station disconnecting switches will be interlocked with the circuit breakers and the other disconnecting switches in the same station which these will be meet by using the auxiliary switches.

Based on the station requirements, the auxiliary switches will be designed to meet the operation position indication, signaling, alarm and interlocking system requirements.

Auxiliary switches will be mechanically operated and the number of normally open and normally closed auxiliary contacts required for interlocking system in addition to the contacts used in control circuits of disconnecting and earthing switches will be as specified.

Early and late acting auxiliary switches will be provided as required by control scheme. The timing of these switches in relation to movement of the main contacts will be as follows:

Early close contacts - These will close before the main contacts close and open after the main contacts open by a margin of not less than 20% of the main contacts travel.

Late close contacts- These will close after the main contacts close and open after the main contacts open.

Late open contacts-These will open after the main contacts close and close before the main contacts open.

Early open contacts - these will open before the main contacts close and close after the main contacts open by a margin not less than 30% of main contacts travel.

All control circuits will be connected to terminal block. The block will be positioned so as to facilitate the connection of all wiring and to avoid interfering with equipment installed in mechanism box. The terminal block will be chosen for the connection of single wire conductors of 2.5 to 10mm² area.

TABLE 1: RATINGS AND CHARACTERISTICS OF DISCONNECTORS AND EARTHING SWITCHES

Item	Description	Technical Particulars	Unit
1	Type of disconnector	Horizontal center break	
2	Applicable standard	IEC 62271-102	
3	Class	Outdoor	



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4	Number of poles	3	
5	Rated frequency	50	Hz
6	Rated voltage	245	kV
9	Whether single phase or 3-phases group driving	3-phases	
10	Min. creepage distance	7595	mm
11	Rated lightning impulse withstand voltage: To earth across open circuit breaker	At IEC condition 1050 1050	kV
12	Rated 1 min. power frequency withstand voltage: To earth across open circuit breaker	At IEC condition 460 530	kV
13	Rated normal current at site condition	As per SLD	A
14	Rated short time withstand current	As per SLD	kA/Sec
15	Rated peak withstand current	2.5xIsc	kA
16	Type of interlock	Mechanical & electrical	
17	Operating mechanism: Type of mechanism Motor voltage Rated control voltage Heater voltage for motor operation mechanism Number and type of auxiliary switches Degree of protection of operating mechanism	Motor operation 110VDC 110VDC 220VAC 18NO+18NC IP 55	

2.3 Current Transformers

The current transformers will be oil-immersed, self-cooled type transformers with dielectric insulation as appropriate.

The current transformers will be suitable for installation outdoors on supporting structures. The output of each current transformer will be suitable for the correct working of the related protection devices and instruments over the required range of load and fault duties.

When multi-ratio transformer windings are specified the requirements will be met by the use of tapings on the secondary windings.

For establishing primary and secondary connections a proper arrangement will be considered.



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All parts exposed to corrosion will be made by non-corrosive material, or be hot-galvanized to a thickness as specified in ISO-1461.

Current transformers will be equipped with a secondary terminal box with sufficient holes and cable glands for cable connection. The terminal box will be spacious enough to allow connection of necessary connecting leads and short circuiting of the current transformer's secondary terminals. The terminal box will be accessible when the current transformer is in operation and also be provided with rain-protected, net-covered, breather holes in accordance with IEC 60529, category IP54. The terminal box will be provided with earthing clamp. All contact components and screws will be of corrosion resistant metal.

A current transformer marshalling box in accordance with IEC 60529, category IP54 will be supplied for every three set of CT's to be mounted near the center phase support structure to provide the interconnection point maintained between winding groups.

For easily short circuiting the secondary terminals of current transformers in marshalling kiosks, suitable terminal blocks with facilities will be provided.

Adequate precautions will be taken to ensure that a uniform stress distribution is achieved throughout the paper insulation. After processing, the insulation will be free of moisture and trapped air.

Each current transformer will be impregnated and filled with oil of the grade specified in IEC-60296 edition 2012.

Each winding will be electrically separated from the other windings. Current transformers may be of the bar, single or multi-turn primary.

Inner insulation will be satisfactorily and permanently protected against moisture.

Associated packing will be resistant to sun, air, oil and water.

Protective cores of current transformers will correctly transform during initial faults and following high speed three phase auto reclose faults without saturation at the maximum fault level and relevant DC offset. The voltage produced at the cores by fault current or during transients on the system will be well below the saturation level to ensure good transient response.

An electrostatic shield will be provided between primary and secondary of CT's for preventing access of high current to secondary's and relays.

Secondary terminals will be located so that they are accessible while the equipment is alive.

Current transformers will be mechanically dimensioned for combined stresses arising from ice load, wind load, tensile forces and movement in connections as well as for short circuit and earthquake forces as specified.

The insulators will be manufactured and tested in accordance with the relevant IEC standards and comply with the requirement of CT's.

If the current transformer has several primary turns or is of the tank type, the primary winding will be protected by an arrester or spark-gap. The spark over voltage will be suitably coordinated with the insulation between primary parts. Current transformers will be designed for horizontal transportation.



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TABLE 1 : RATINGS AND CHARACTERISTICS OF CURRENT TRANSFORMER

Item	Description	Technical Particulars	Unit
1	Type	Oil immersed, Tank type	
2	Applicable standard	IEC 61869-2	
3	Class	Outdoor	
4	Rated system frequency	50	Hz
6	Rated voltage	245	kV
7	Min. creepage distance	7595	mm
8	Rated continuous current	As per SLD	A
9	Rated continuous thermal current	120	%
10	Rated short time withstand current	As per SLD	kA/Sec
11	Rated Dynamic current	2.5×Isc	kA
12	Rated insulation level (at IEC condition): - LIWL - PFWL	1050 460	kV
13	Specifications (ratio, burden, accuracy class, ...)	As per SLD	

2.4 Capacitive Voltage Transformers

Capacitive voltage transformers will have electrically completely separated secondary windings.

Secondary circuits will be earthed at one point only. A separate earth link will be provided for each secondary winding and will be situated at the transformer terminal box.

Each secondary winding will satisfy both metering and protection accuracies according to mentioned technical requirements. The accuracy class of relaying and metering of each winding will be valid from 25% to 100% of rated burden at a power factor of 0.8 lagging, whilst the other winding loaded with 0% to 100% of upper limit of the output range specified for other winding.

The design of capacitive voltage transformers will be such that the accuracy will not be affected by the presence of pollution on the external surface of the insulation.

Capacitive voltage transformers will be suitable for simultaneous use as power line carrier coupling and voltage measuring capacitors.



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Capacitive voltage transformers will be so designed that by the use of an appropriate damping device, Ferro-resonance does not occur and its additional device burden will be considered.

For protection class voltage range will be from 5% of rated voltage to rated voltage multiplied by the rated voltage factor and for metering class 80-120% of rated voltage.

The secondary terminal box will include HRC fuses for protecting secondary circuits.

Capacitive voltage transformers with the same ratings and characteristics will be interchangeable.

All parts exposed to corrosion will be constructed of non-corrosive material, or be hot dip galvanized to a thickness as specified in ISO 1461.

Capacitive voltage transformers will be hermetically sealed. Inner insulation will be satisfactorily and permanently protected against moisture. Associated packings will be resistant to sun, air, oil and water.

Intermediate voltage transformers will be equipped with oil level indicators, preferably of indirect connection to insulating.

If the capacitive voltage divider is provided with a manometer, this will be easily visible and possible to read during operation.

The lower metallic part of the capacitive voltage transformer will be provided with two earthing clamps in opposite sides.

The insulators will be manufactured and tested in accordance with the relevant IEC standard and comply with the requirement of CVTs.

The Insulator to metal joints will be such as to ensure oil tight 'seal is obtained under all loading conditions imposed at the high voltage terminal, particularly during transport to site.

The capacitor elements will be enclosed in oil filled Insulator chamber. The Insulator chamber will be hermetically sealed with oil resistant and weather proof gaskets.

All steps will be taken to ensure free expansion of the oil between the ambient temperatures specified.

Where epoxy resin is used in the primary winding construction, this will serve only to absorb mechanical shock and strain and not be subject to electrical stress. It will not be directly exposed to atmosphere.

All measures will be taken to protect the high frequency coupling terminal against rain and vermin when in use, so as to avoid the possibility of being shorted to earth. The capacitor voltage transformer will fully comply with the applicable requirements of PLC coupling.

Appropriate provisions will be made to enable high frequency carrier signal to be coupled to the capacitor unit. The low voltage terminal, as per IEC 60358 will be suitable for connection either to earth terminal or HF equipment.

Secondary terminal box of capacitive voltage transformer will be equipped with gland plate of adequate size to allow connection of necessary cables to be carried out comfortably. The terminal box will be accessible when the transformer is in operation and also be



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provided with rain- protected, net covered, breather holes, in accordance with IEC 60529, category IP54. All Metal parts in this box will be corrosion resistant.

All terminal boxes will be equipped with:

- One set of terminal blocks
- One set of fuses with remote indication facilities
- Grounding terminals for earthing secondary windings
- Secondary terminal and earthing clamps will be suitable for connection of up to the 10 mm² stranded conductor.

CVTs on busbars and cut-off nodes, which uses for synchronizing purposes, will be single phase.

2.4.1 PLC coupling requirements

Coupling capacitor will be suitable for transmission within frequency range 40-500 kHz. Equivalent series resistance of coupling capacitor will be smaller than 40 ohm within 40-500 kHz.

Natural frequency of coupling capacitor will be higher than 1 MHz.

Coupling capacitors will be designed to withstand a steady high frequency current through the coupling capacitor of at least one amp.

TABLE 1: RATINGS AND CHARACTERISTICS OF VOLTAGE TRANSFORMER

Item	Description	Technical Particulars	Unit
1	Type	Oil immersed	
2	Applicable standard	IEC 61869-5	
3	Class	Outdoor	
4	System neutral earthing	Effectively earthed	
5	Min. creepage distance	7595	mm
6	Rated system frequency	50	Hz
7	Rated voltage	245	kV
8	Rated insulation level (at IEC condition): - LIWL - PFWL	1050 460	kV
9	Rated voltage factor: Continuous 30 Sec.	1.2 1.5	



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10	Number of secondary winding	2	
11	Rated primary winding voltage	As per SLD	kV
12	Rated secondary winding voltage	As per SLD	kV
13	Specifications (burden, accuracy class, ...)	As per SLD	

2.5 Line Trap and Coupling Device

Line traps will mean all single phase, air cored inductor of dry type with natural air cooling and with protective and shunt tuning device intended for series in section into a high voltage power transmission line, complete with all necessary accessories for proper operation.

The line trap will be suitable for use at the specified site and environmental conditions. The line trap will be designed for outdoor mounting separately on post insulator or suspension.

The line trap and its terminals will be properly designed to withstand all static and dynamic forces as specified.

Insulating materials will be moisture and fungus resistant and will withstand high content of ultra violet rays.

The line trap will be designed to operate in a dusty atmosphere with relative humidity's and between outdoor temperatures ranges specified. The equipment will be designed such that it will operate correctly after being stored in an environment ranging specified.

The insulation of the main coil and tuning device of line trap will be adequately rated for site conditions.

Line traps will be of robust construction and all metallic parts will be of non-magnetic material. Exterior sharp corners will be avoided. Lugs for lifting and lightning arresters will be provided.

Color of line trap will be suitable for specified environmental conditions.

The line traps will not generate excessive radio frequency noise more than specified value. The equipment will withstand the earthquake forces resulting from specified ground acceleration and full evidence to substantiate this claim will be supplied by tenderer.

Terminals of copper or a copper alloy will be tinned to a thickness of minimum of 50 micro meters. A copper alloy which is sensitive to season cracking will not be used.

Terminals of aluminum or aluminum alloy will not be treated. The aluminum alloy will have almost the same cracking constancy as pure aluminum. An alloy sensitive to season cracking, layer corrosion or inter-corrosion will not be used.

A module plate terminal of aluminum or aluminum alloy will have a hardness of minimum 750N/mm².



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Coupling device, which will be inserted between the low voltage terminals of the coupling capacitor and the carrier terminal equipment will consist of a line matching unit which matches the impedance of the line side to the PLC terminals, protection unit providing protection for the carrier terminal equipment against over voltage surges, balancing unit, hybrid transformer and separation filter.

The line coupling unit will be suitable for outdoor duty and are to be mounted on the steel framework which supports the coupling capacitors. All equipment parts of the line coupling unit will be enclosed in a metal box of IP54 with hinged, front access.

The coupling unit will include, but will not be limited to the following coupling and protection devices:

- A tuned and replaceable coupling transformer which, together with the coupling capacitor will form a broadband high pass filter arrangement which will match the output impedance of the power line, phase-to-ground or phase-to-phase or three phase, over the range of frequencies to be transmitted and received.
- A disconnect and grounding switch which will be used to ground the coupling capacitor output lead. This switch will be capable of withstanding the specified current without damage and its open and close condition will be visible.
- A primary high voltage discharge arrester which will be set to conduct when a potential is applied across its terminals. The arrester will be capable of protecting the coupling unit even under the rare case where the coupling capacitor may become shorted.
- A drain coil which will be connected to the output lead of the coupling capacitor to provide a low impedance path to ground for the 50 HZ component of incoming voltage and current. It will not attenuate the incoming/outgoing carrier signal level by an amount greater than 0.5 dB over the usable carrier frequency range and will withstand over voltages.
- A fuse which will limit the current allowed to flow in the coaxial cable connecting the coupling unit to the power line carrier equipment. This fuse will have sufficient breaking capacity so that there is no risk of flashover between its terminals. After fusion of the fuse wire. When a specified high voltage recovery voltage is applied.
- A secondary low voltage discharge arrester.
- Earth terminal of coupling device which is intended to be connected directly to the local station earth.
- Primary terminal of coupling device which is intended to be connected to the low voltage terminal of the coupling capacitor.
- Secondary terminal of coupling device which is intended to be connected to the coaxial cable.

Coaxial cable will be used to connect the outdoor coupling equipment to the indoor carrier set.



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The characteristic impedance of the cable will match with the nominal equipment side impedance of the coupling device and PLC terminal impedance and will have specified loss.

The coaxial cable connecting unit will be provided for the joining of the outdoor coaxial cable to the indoor coaxial cable which is connected to the PLC terminal equipment.

The coaxial cable connecting unit will provide the following:

- Adequate screening of the inner conductor
- Protection against electrical danger caused by exposed terminals and armoring for protection against mechanical damage.
- Negligible mismatch of the line
- Solid earthing for the outdoor coaxial cable
- Provision for connecting a load equal to line impedance for test

The characteristic impedance of the cable will match that of the carrier set which is nominally 75 ohms unbalanced, and will have a loss of not more than 0.15 dB per 100 meters at 100 kHz.

The coupling equipment will effectively transmit to and receive from the line, without undue loss.

The coupling device will be designed and built to ensure that a fault on the power line will not in general cause a permanent interruption in the functioning of the coupling device.

The coupling device will be so designed that the impedance at power frequency between the primary terminal and the earth terminal is as low as possible and in no case in excess of 20 Ω .

TABLE 1: RATINGS AND CHARACTERISTICS OF LINE TRAP AND LMU

Item	Description	Technical Particulars	Unit
1	LINE TRAP		
1.1	Type (Insulated/non-insulated/fixed/adjustable, single freq. / wide band-tuned, ...)	Non - Insulated/ wide band Tuned	
1.2	Applicable standard	IEC 353	
1.3	Class	Outdoor	
1.4	Rated system frequency	50	Hz
1.5	Rated system voltage	245	kV
1.6	Rated continuous current	As per SLD	A
1.7	Rated short time withstand current	As per SLD	kA/Sec
1.8	Rated Dynamic current	2.5xIsc	kA
1.9	Rated inductance (at 100kHz)	As per SLD	mH
1.10	Blocking frequency bandwidth	64-400	kHz



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1.11	Min. blocking impedance guaranteed within specified bandwidth	600	Ω
1.12	Max. tapping loss	<2.6	dB
1.13	Characteristics of protective device: Type Rated voltage Nominal discharge current Line discharge class as per (IEC60099-4)	ZnO <20 10 2	kV kA
1.14	Rated insulation level of tuning device: Power frequency withstand voltage Lightning impulse withstand voltage	>25 >75	kV
1.15	Method of mounting	Suspension	
2	LMU		
2.1	Type of coupling (phase to phase/phase to earth/three phase)	Phase to Phase	
2.2	Applicable standard	IEC 481	
2.3	Class	Outdoor	
2.4	Bandwidth	40-500	kHz
2.5	Retune loss	>12	dB
2.6	Composite loss	<2	dB
2.7	Withstand current / time of disconnect and grounding switch	5 / 1	kA / Sec.
2.8	Breakdown voltage of primary and secondary arresters	0.6	kV
2.9	Input impedance : Balance Unbalance	125 75 / 125	Ω

2.6 Lightning Arrester

Lightning arrester will mean metal oxide non-linear resistor type, heavy duty station class, and single pole.

The arresters may be installed at the termination of transmission lines, near power transformers, shunt capacitor bank, shunt reactors or connected to station busbars.

Each arrester composed of one or more individual units which the number of them depends upon the rated voltage of arrester.

Arrester will be designed, manufactured and tested in accordance with the applicable requirements of this specification and latest revision of IEC 60099, included all amendments, supplements and references publications listed within the above standard.

Arresters will be suitable for use at the specified site and environmental conditions.

The impulse spark over volt-time characteristic of the arrester will be practically flat.



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The method of assembly of the arrester will be such that adequate contact pressure is at all time maintained between the faces of the series non-linear resistance blocks.

The design of the series gap and voltage grading resistors will be such that the gap setting cannot be affected by vibration, mechanical shock or change in temperature.

The design will be such that the protection level will not be affected by pollution of the external insulation. All joints will be made in a proper manner such that the diverter is hermetically sealed with material which will not deteriorate under any service conditions.

The sealing of arrester will be such that it will not be affected by transportation and live washing of arrester will be possible while in service.

The arresters will be mechanically dimensioned for combine stresses from tensile force of terminals, wind and ice load as well as earthquake forces.

The arresters will be self-supporting for structure mounting (horizontal or vertical) and will be supplied with line and ground terminals.

Housing of arrester will be made of insulator that will be designed, manufactured and tested in accordance with the relevant IEC.

All components exposed to corrosion will be made of non-corrosive material or be hot-galvanized according to ISO-146 I.

The design of the arresters will be such that a reasonably uniform potential drop exists across each section of the arrester regardless of any distortion of the electrostatic field or the presence of environmental condition.

Arresters will not cause radio interference except during discharge.

The arrester units will be interchangeable with like rated units of the same type.

The arresters will be designed to facilitate inspection.

Metal oxide non-linear resistance blocks will have uniform thermal and current density distribution. The material design of non-linear resistance blocks will be such that under specified severe condition especially under temporary over voltages, thermal runaway will not occur.

Surge counters will be designed for continuous service .Surge counters will be of static components with the electromechanical type counter and suitable for continuous service without requiring any auxiliary source.

They will be robust and capable of withstanding repeatedly without damage, the maximum discharge current of the arrester. Internal parts will be unaffected by atmospheric conditions on site.

The counter will be connected in the main earth-lead from the arrester in such a bolted links will be provided so that the surge counter may be short circuited and removed without taking the arrester out of service.

The arrester base will be insulated from the ground and connected to the counter by insulated cable. The output terminal of counter will be earthed directly by bare copper



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conductor. The insulated cable and bare connections will have adequate thermal and Electrical, mechanical strength for the duty they are employed for.

TABLE 1: RATINGS AND CHARACTERISTICS OF SURGE ARRESTER

Item	Description	Technical Particulars	Unit
1	Type of surge arrester	MO	
2	Applicable standard	IEC 60099	
3	Class	Outdoor	
4	Rated frequency	50	Hz
5	Maximum system voltage	245	kV
6	Continuous operating voltage	198	kV
7	Rated voltage	158	kV
8	Max. residual voltage for lightning impulse current with 8/20 Microsecond wave shape with following peak values of impulses:		kV
	5kA	< 460	
	10kA	< 485	
	20kA	< 545	
9	Max. residual voltage for lightning impulse current with 8/20 Microsecond wave shape with following peak values of impulses:		kV
	1kA	< 405	
	2kA	< 425	
10	Max residual voltage for steep current impulse with 1/4 μ s wave shape with 10kA peak values of impulses	<515	kV
11	Nominal discharge current	10	kA
12	Line discharge class as per IEC 60099-4	3	
13	Max internal partial discharge at 1.05.UC	<10	pC
14	Pressure relief capability	Isc@0.2Sec	KA/sec
15	External insulation:		
	Type	Porcelain/Polymer housing	
	Min. creepage distance	7595	mm
	Rated power frequency withstand voltage	460	kV
	Lightning impulse withstand voltage	1050	kV



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16	Whether surge counter is equipped with leakage current measuring device (YES / NO)	YES	
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2.7 Switchyard Buswork

2.7.1 Conductors

The minimum requirement for conductors will be as indicated for new substations (AAA type). Conductors and their supports will be designed to withstand the forces resulting from the combination of short circuits and wind as described below, without exceeding the stress and deflection limits specified in the following paragraphs.

The conductors will comply in all respect with the latest revision of standard DIN48201 and the cross section of conductors will be based on substation's electrical and mechanical requirement.

Conductors will be free of audible and visible corona. The corona free requirement will be applicable under all environmental conditions. Voltage stress shall not exceed an equivalent value of 18.5 kV/cm at sea level.

Under normal conditions, final temperature will be 85 °C for stranded aluminum conductors.

Conductor will be able to withstand the short circuit currents specified for 1 second without exceeding a final temperature of 200 °C.

The design of the conductor's type and size will allow for swinging during short circuits without damaging the connections, busbars and equipment's.

Bus conductors, their supports and connectors will be designed to withstand the forces resulting from the combination of short circuits, wind, and earthquake and ice load according environmental condition without exceeding the stress and detection limits.

2.7.2 Rigid Bus

- Aluminum tubes and frames will be manufactured of hardened aluminum alloy of the E- Al-Mg-Si type F22 (ENAW-1350 STATE F). This alloy will fulfill the demand presented in ASTM B317.
- Welding will be avoided by locating post insulators at suitable distance. Aluminum welding will be appropriate for environmental conditions.
- Rigid bus to rigid bus connections will be made by appropriate type of connectors fitted at post insulators.
- Jointed tubes will have the same electrical and mechanical properties as the un-jointed tube.
- Jointed tubes will have a minimum tensile strength equal to 72% of specified for the un-jointed tube.
- Tubes will be able to withstand the short circuit currents specified for 1 second without exceeding a final temperature of 200°C. Initial temperature will be considered 85°C.



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- (g) Rigid bus will be sized to limit sag or deflection under dead loads to $1/150$ of the unsupported length (without ice).
- (h) The natural frequency of vibration for any span of rigid bus shall not be less than 2.5 cycles per second.
- (i) Provision will be made for expansion and contraction of elements due to temperature variations as well as relative displacements of supporting structures. Expansion fitting will be located as required.
- (j) Taps to rigid bus or connection of rigid bus to equipment terminals will be made via an ANSI 4- bolt terminal bolted to the tube (with expansion connector if required).
- (k) End caps or corona bells will be installed in tubular bus to prevent the intrusion of moisture.
- (l) Rigid bus will be arranged in a manner such that it can be extended without difficulty.
- (m) Precautions will be taken as required to limit vibration in tubular buses, either through the installation of a damping cable or insertion type torsional dampers within the tube. In those instances where damping is not provided during construction and vibrations occur during field trials, damping will be installed as directed by the Engineer in those sections of bus subject to excessive vibration, In general damping will be required when ratio of span length to bus diameter exceeds 50. The weight of the cable should be from 10% to 33% of the tube weight.
- (n) The minimum factor of safety, considered in the design of tubular conductor base on the tube yield limit will be 1.5 under load combination without earthquake and/or short circuit force and 1.1 under load combination with earth quake and/or short circuit force.

2.7.3 Lightning protection

The station structures and equipment will be effectively protected and earthen against direct lightning-stroke by shield wire conductor and air rod.

Horizontal shielding conductors supported by the main structures, and lightning masts (if necessary) will be used to shield the station.

The design method will be based on DIN VDE 0101.

The overhead shield wire will be stranded, alum weld steel core wire

2.7.4 Insulators

Each insulator will be marked with the initials or trademark of the manufacturer, year and location of manufacture, the date of firing. Each insulator will also be marked with the guaranteed electromechanical strength. All marks will be imprinted before firing in such a manner that the marks will be permanent and clearly legible on the finished insulator. Also each insulator will be marked as required by IEC 60383 together with such other marks as may be required to assist in the representative selection of batches. Aluminous or Portland cement will be used as the bonding agent between the porcelain and metal parts.



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The porcelain will be manufactured by the wet process and will be of homogeneous structure, free from laminations, cavities, or other flaws. It will be well vitrified and nonporous. It will have a brown colored glazed.

The insulators will be designed to keep radio interference at a minimum and will be of the "Corona Free" type. Any treatment will be impervious to the elements.

The safety factors to be used for insulators with regard to the electro - mechanical failing load shall be:

- Static loads	2.5
- Dynamic loads,	(short circuit, earthquake):
- Post insulators	1.25
- String units	1.5

2.7.5 Post insulator

Solid post insulators will be completed with all necessary metal parts for attaching the insulator to the clamps and steel structures.

Post insulators will be mechanically dimensioned according to IEC 60273 and for stresses arising from ice load, wind load, tensile forces and movement in connections as well as for short circuit and earthquake forces as specified.

Post insulators will be electrically strong enough to withstand lightning impulse and switching impulse power frequency withstands voltage specified.

Post insulators will comprise of fully interchangeable units of solid core cylindrical type. The completed units will be uniform in height and bolt locations for each voltage rating so that they will be interchangeable.

Insulating surfaces will be parallel, and the galvanizing on the faces will be uniform and smooth, to insure proper sealing of surfaces when they are bolted together.

The torsion imposed on the insulator is the bending moment on the end of bus, due to the wind load and to the short circuit current electromagnetic force on the bus. To determine the torsion value, the end of the bus bar will be taken as completely fixed.

The insulators will be subjected to a porosity test in accordance with ANSI C29.1, "Test Methods for Electrical power Insulators".

2.7.6 String insulator

String insulators unit, will be of cap and pin type. They will be complete with all fittings for attaching the insulator unit together to make a string. Fittings made of steel will be hot dip galvanized.

The insulator shells will be made of wet process brown glazed porcelain, toughened glass or silicon rubber, anti-fog type with corrosion proof zinc sleeved insulators (for very heavy pollution level) or standard type (for light and medium pollution level).

The insulator units will have metallic caps and pins, with ball and socket fittings, securely cemented to the insulators.



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The locking devices will be of copper alloy with not more than 15% zinc content or stainless steel split-pin, suitable for hot-line maintenance. The locking devices will be such that when set only extreme deformation of the retaining pin or locking device will allow separation of the insulator units or fittings. Their design will allow easy removal or replacement of the insulator units or fittings. A common design of retaining pin or locking device will be used.

The cap and pin will be made of high-grade forged steel and machine-faced. .

All ball and socket joints of insulator sets will be lightly coated in the factory with proper grease.

No insulating part will be subjected to any mechanical stress due to pressure exerted by the bottom edge of the cap.

All fittings and accessories will be dimensioned for the prescribed short-circuit current and time.

2.7.7 High Voltage Connectors and Terminals

2.7.7.1 Module plate terminals

Terminals will normally be of module plate type. Terminals of maximum rated current up to 1600 Amps will be designed as a plate of 75x75x15mm (L xWxH).

Terminals for rated current up to 3150 Amps will be designed as a plate of 125x125x35mm (LxWxH).

A copper alloy which is sensitive to season cracking shall not be used. Terminals of aluminum or an aluminum alloy shall not be treated. An alloy sensitive to season cracking, shall not be used.

A module plate terminal of aluminum or aluminum alloy will have a hardness of minimum 750 N/mm².

2.7.7.2 Pin Type Terminals

Terminals for maximum rated current 1600 A will be designed as a pin of 125mm length and having 30±0.15mm diameter.

Terminals for maximum rated current 3150 A will be designed as pin of 125mm length and having 60±0.2mm diameter.

The terminals for copper (Cu) or a copper alloy will be tinned to thickness of minimum 50 micro meters.

2.7.7.3 Connectors and Clamps

Current carrying connectors for identical conductors will have at least the same conductivity as the conductors they connect. With rated continuous current, the temperature rise of the connector and the surrounding conductors will not exceed that of the conductor measured on its free length.



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Current carrying connectors for different conductors will have at least the same conductivity as the smaller conductor. With rated continuous current, the temperature rise of the connector and the surrounding conductors will not exceed that of the warmest conductors measured on its free length.

For the specified short circuit current and duration, the temperatures will not exceed that of the conductors they connect.

Parts of current carrying connectors which are in direct contact with the conductor will be designed so that dangerous galvanic corrosion in the contact surface in question cannot occur.

All materials in a connector will be able to withstand temperatures up to +100°C without becoming brittle or lose their mechanical or electrical properties.

Contact surface will be machine finished with small tolerances and high accuracy and protected to prevent the build-up of non-conducting oxide.

The connectors will not cause radio interference above the laid down limits for the projects. Sharp edges will be avoided in design.

Connectors will be designed to allow uniform current distribution in the conductor through the shortest current path. Eddy current and hysteresis losses will be small.

Aluminum connectors will be made of aluminum or aluminum alloy, free of copper with resistance to corrosion as near as possible to that of aluminum, according to SIS 144008.

The aluminum surface of the connectors will be factory made oxide free by grinding, etching and application of special coating.

Wherever a copper aluminum connection is made, the contact surface of the copper will be tin-plated in order to avoid electrolytic corrosion.

Connectors between aluminum conductors and apparatus terminals of aluminum or copper will consist of aluminum connectors in combination with a suitable contact paste.

Flexible connectors between tube and terminal will have the minimum possible effect on the terminals as regards tensile, bending and wrenching stresses.

Flexible connectors will permit the movements, withstand the stresses and maintain the allowable ground and phase distance.

Flexible connectors between aluminum tube and terminal will effectively reduce mechanical swinging of the aluminum tube without any appreciable damage to the tube, and without any butt-action on the terminal.

During short circuits, the tubes in flexible connector are subjects to a short dynamic load. The tubes will therefore be supported so that no butt-shock can be transferred to the terminal on account of the tube acceleration as a result of this dynamic load.

Clamped connectors will be provided with conductor groove for each conductor.

Clamped connectors between wires or wires and homogeneous conductor will be provided with separate caps for the connected conductors.



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Clamps over conductor and terminal lugs will be divided with two bolts in each partial clamp and one screw on either side of the conductor.

Conductor grooves for aluminum, which are discontinued within the bolted connector, will be completed by a notch for the cable end's locking device. This notch will be at least 8mm long and be least 2mm deep, reckoned from the contact surface or the conductor groove.

Crimped connectors as well as the installation tools will be made so that fractures do not occur that could reduce the mechanical and electrical qualities of the conductor and connector.

Crimped connectors will be designed to prevent water penetration. If this cannot be prevented, then the drainage holes will be provided.

Crimped connectors will be provided when possible with marks to indicate where crimping is to be carried out.

The bus support clamps will be so dimensioned that clashing between the aluminum tube and the clamp does not occur during short circuit.

The bus support clamps will not be notably heated by hysteresis or eddy current losses. The bus support clamps for continuous tube will allow the following:

- Unlimited movement of tube in its axial direction with respect to the clamp
- Locking to prevent axial movement with respect to the clamp without the insulator being affected by butt torsional influence
- Setting the tube in any direction in the horizontal plane with respect to the assembly plane of the insulator
- Setting the tube in the vertical plane in any direction within $\pm 15^\circ$ with respect to the assembly plane of the insulator.

The tubes will be prevented from falling out of the flexible bus support clamps.

Suspensions clamps will be free to pivot in the vertical plane about a horizontal axis passing through and transverse to the center line of the conductor. Suspension clamps will permit the complete conductor to slip before failure of the later occurs, but the conductor will be clamped in a proper manner.

Ferrous suspension clamps for conductors with outer aluminum strands will be provided with soft pure aluminum liners to protect the conductor.

Tension clamps will be of the compression type. The mechanical efficiency of such tension clamps will not be affected by methods or erection involving the use of aux. erection clamps before, during, or after assembly and erection of the tension clamp itself.

Welded connector parts in flexible aluminum connectors will be made according to the Argon-MIG method.

Welded connectors will be made so that water is prevented from penetrating the connector.

Welds will not be subjected to fatigue stresses.

TABLE 1: RATINGS AND CHARACTERISTICS OF BUSWORK



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ITEM	DESCRIPTION	230 KV
A	<u>String Insulator Unit</u>	
1	TYPE	BALL & SOCKET
2	Applicable standard	IEC 60383
3	Insulator material	Porcelain
4	Color	Brown
5	Minimum electromechanically failing load KN	160
B	<u>String Insulator Complete</u>	
1	Insulator material	Porcelain
2	Applicable standard	IEC 60383, IEC61109
3	Total creepage distance of string.....mm	7595
4	Size of ball and socket.....mm	20
5	Material of fittings.....	Cast Iron
6	Power frequency withstand voltage at sea level (kV rms.)	460
7	Lightning impulse withstand voltage at sea level(kV peak)	1050
8	Switching impulse withstand voltage at sea level(kV peak)	N.A.
9	Whether arcing ring at ground side Provided.....(yes/no)	Yes
10	Whether grounding ring at live side provided.....(yes/no)	Yes
11	Whether washable in service.....(yes/no)	Yes
C	<u>Post Insulators</u>	
1	Insulator material	Porcelain
2	Color	Brown
3	Applicable standard	IEC 60168
4	Power frequency withstand voltage at sea level (kV rms.)	460
5	Lightning impulse withstand voltage at sea level(kV peak)	1050
6	Switching impulse withstand voltage at sea level(kV peak)	N.A.
7	Total creepage distance of string(mm)	7595
8	Top & Bottom metal fitting material	Cast Iron
9	Minimum cantilever KN	8
10	Whether washable in service.....(yes/no)	Yes
D	<u>Stranded Conductor</u>	
1	Material	AAAC
2	Applicable standard	DIN 48201



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3	Nominal cross section	will be finalized at design stage
4	Continuous current rating of conductor at max. ambient temperature and 80° conductor Temperature A	
	Rated current for :	
	• Line feeders	2000
	• Transformer	2000
	• BUSBAR	as per SLD
5	Short circuit current	as per SLD
E	<u>Tubular Conductors</u>	
1	Material	E-AL Mg Si 0.5 F22
2	Applicable standard	ASTM B317
3	Outside diameter	will be finalized at design stage
4	Thickness(mm)	6
5	Continuous current rating of conductor at max. ambient temperature and tube temperature 85° A	
	• Line feeders	2000
	• Transformer	2000
	• BUSBAR	as per SLD
6	Short circuit current	as per SLD
F	<u>Shield wires</u>	
1	Material	ACS
2	Applicable standard	ASTM B416
3	Cross section mm ²	58.43
4	Diameter mm	9.78
5	Number of strands	7
G	<u>Connectors and Hardware</u>	
1	Material.	Aluminum (for clamps) / forged steel (for SI Acc.)
2	Material of bolts and nuts	Stainless Steel
3	Material of washers	Stainless Steel
4	Applicable standard for connectors	NEMA CC1
5	Short circuit	as per SLD



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2.8 Protection

Control equipment comprises equipment for indication, registration, signaling, protective functions and apparatus for manual and automatic control and regulation.

2.8.1 Protection system

The minimum possible part of the plant will be tripped to isolate fault or clear the abnormal conditions. In addition, the fault will be tripped within the time necessary for personnel protection, reasonable restriction of material damage, etc. and before damage has time to occur in the event of abnormal operating conditions.

All functional requirements on the relay protection will be satisfied for short circuit current and associated impedances at the maximum, minimum and intermediate values.

Owing to high source - side fault level, high source reactance to resistance (X/R) ratio at busbars, necessity of using similar CT's in bays, criterion of limiting CT knee point voltage, single-shot auto re-closure requirements with duty cycle as 0-.3sec - CO - 3min - CO, cable distances, requirements of protection time not to exceed the required time in last auto-re-closure shot under worst maximum and minimum DC offset including CT pre-saturation conditions, large number of relays, recorders, fault locators connected on CT cores and all other technically required features, the contractor will propose the relays & devices having lowest burdens & CT knee point requirements for various type of relaying.

2.8.2 Inter-tripping (transfer tripping scheme)

The inter-tripping function shall generally be achieved by using dual channel transfer trip scheme using audio-frequency shift tones on P.L.C. except for radial lines without remote end generation.

This function is required to clear the abnormal conditions at local substations and a definite or provisional tripping whichever the case may be of the remote end C.B's.

These abnormalities shall generally be including the followings,

- a) Line over voltage due to excessive MVAR generations.
- b) Transformers and reactor feeders without C.B on HV side.
- c) Circuit breaker failure conditions and short zone protection.

2.8.3 Relay Panel D.C. Circuit Supervision

The D.C. supply to the protections in each relay panel supplied will be supervised via an auxiliary relay. An alarm will be initiated on the loss of the D.C. supply.

The relay will be so positioned to detect the failure of interconnection circuit of D.C. supply to all the relays and protection devices within the panel.

2.8.4 Circuit Breaker Protection Schemes

All the control/protection schemes finally operate the circuit breaker. The following relays/systems shall generally be followed for each circuit breaker.

1. Auxiliary supply
2. Breaker-failure protection



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3. Pole-discrepancy protection
4. Trip circuit supervision relays
5. Close coil supervision
6. Short zone protection

2.8.5 Testing Facilities

All relay protection will be capable of being tested individually (even during normal operation) with adequate safety of the test personnel and without the risk of spurious tripping. Various partial protection functions for a given primary object shall include facilities for individual testing with the other protection in operation. When testing the protection in sub 1 or 2 it is not acceptable that the protective functions in the other sub system are blocked or activated.

2.8.6 Breaker Failure and Pole Discordance Protections

The breaker failure protection is a supplement to the relay protections of the various objects and is located together with these protections, e.g. transmission lines, transformers and reactors connected by means of their own breakers.

The function of the breaker failure protection will be dependent on the circuit breaker auxiliary contacts (acc to IGMCC Requirements & Instructions) and will consist of current relays which determine whether or not the interrupting has been satisfactorily carried out. The breaker failure protection function will be available for all faults.

The breaker failure protection will be actuated only when the relay protection applies a tripping order.

The breaker failure protection will be designed with a high degree of safeguard against spurious operation.

When actuated, the protection will instantaneously apply a tripping signal to the same breaker which the protection monitors and if this attempt is not successful the breaker failure protection will trip all adjacent and relative breakers at the second step after an adjustable time delay.

In addition to the breaker failure protection, all breakers will be equipped with a separate pole discordance protection.

The pole discordance protection will use the auxiliary contacts in the different poles of the breaker. The function will be time delayed in two steps with specified value.

The first step will trip the breaker with discrepancy and will initiate the breaker failure protection. If the attempt to trip the breaker from the first step in the pole discordance protection is successful the function of breaker failure protection is inhibited.

All adjacent breakers will be tripped by the breaker failure protection after an adjustable time delay as the second step for pole discordance protection.

During single phase auto-reclosing, the pole discordance protection will be blocked.



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In addition to breaker failure and pole discordance functions, Short zone protection should be provided for each breaker. This protection should be included in CBF relay with settable current and operating time dependent on the position of the breaker.

2.8.7 Circuit Breaker Trip/Close Coil Supervision

Each trip/close coil of breaker will have individual trip/close relay. The trip relays will be supplied in Sub-I and Sub-II and close relays will be supplied in sub-I or sub-II protection systems.

Each and every trip/close coil of the circuit breaker, its power supply and trip/close circuit wiring between relay panel to switchyard and CB trip/close coil will be supervised by trip/close coil supervision relays. The trip coil supervision will be provided for both circuit breaker tripping circuits.

They will be arranged to initiate an alarm and visual indication if trip/close circuit of CB fails.

2.8.8 CVT Fuse Failure Supervision

All 3 phase CVT Secondary's will be supervised by 3 phase CVT fuse failure supervision circuits. CVT fuse failure supervision circuits based on auxiliary relays are used merely in control and measuring circuits. But for the protection functions whose operation is based on voltage (like Distance function) and for which the operation speed of the fuse failure function is so vital, the internal fuse failure function (97FF) designed inside the relay will be used. The maximum operating time of the fuse failure supervision circuits will be less than 20 msec.

The operating speed of the internal fuse failure function (97FF) inside the protection relay will be fast enough to inhibit undesired operation of high speed relays (e.g. distance). The operating time will be less than 8 msec.

Since this relaying can mal-operate under voltage unbalance conditions due to line charging and single phase auto reclosing conditions, the functions to bypass the distance relay blocking from fuse failure relaying for manual line charging and dead time of auto reclosure relay will be provided.

2.8.9 Tripping Circuits and Relays

The tripping circuits for the relay protection belonging to Sub-I and Sub-II or main and backup will be entirely separate electrically and mechanically. They will not include common switching devices, connectors, terminal blocks, cables, auxiliary relays etc.

Each tripping coil of the breaker will be supplied via individual trip relays. The operating time of the self-reset trip relays should be less than 10 msec. Furthermore, each circuit breaker will be supplied with one Lockout relay.

2.8.10 Line Protection

230kV transmission line protection will be divided in sub 1 and sub 2 categories comprising of the following main protection relays, however for accurate protection requirement reference will be made to protection single line diagram of each respective substation.



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Note: The protection relays should be considered according to IGMC Requirements & Instructions.

a) Sub I protection

The integrated /separated protection shall consist of following features.

1. Distance protection (21P+21NP)
2. Tele-protection schemes for distance and directional earth fault (85)
3. Power swing Blocking
4. Switch on to fault
5. Directional earth fault protection (67N).
6. Fuse failure supervision (97)
7. Stub protection (50 STB)
8. Under voltage protection (27)
9. Over voltage protection (59)
10. Trip order devices (94+86)
11. High speed auto re-closer (79)

a.1) Distance Protection

The performance requirements for various zones of distance relaying will be as follows:

The distance relaying will be 4 zone, static type, and "non-switched full scheme" design without the use of any starting relays. The relay will selectively operate for all types of faults with high degree of security against spurious tripping due to any type of power system or auxiliary system transients.

Zone 1 will have high speed clearance of faults at midpoint of the protected circuit. The operating time will be short.

First zone should protect 80% to 90% of the line. The operating time will be less than 20 msec.

For all three zones, the relay will provide high stability against tripping for all faults behind the relay location, and for those beyond the remote termination in direction of forward reach.

The relay will have restricted reach on either side of the locus of solid faults to discriminate against through load and power swing conditions and against healthy phase impedances, etc. It will also have controlled reach in the fourth quadrant of the complex R-X Impedance plane to cater for closing-in arcing fault.

Zone 2 unit will have time graded protection for faults within the protected circuit and for those in a selected part of adjacent circuit in the direction of forward reach. Second



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zone should cover whole of protected line section plus up to 50% of the next shortest line section.

The characteristics will then cover the remote section of protected circuit not covered in zone 1 and provide partial backup protection to the main protection of the circuits.

Zone 3 unit will also have time graded tripping for faults within the protected circuit and ideally cover the whole of the following circuits immediately, irrespective of the fault in-feeds at the intermediate busbar. Third zone should cover adjacent line sections plus 25% into the longest third line.

The protection scheme will be achieved by permissive under reach type inter-trip scheme. Extension of under reach step acceleration is acceptable on receipt of the signal.

However, the distance relaying will be provided with high set instantaneous over current unit for clearance of 3 phase bolted faults (close-up faults) while the line is energized. This protection will be available only up to say 0.3 seconds from the instant of energizing the line.

All zones will be provided with zero sequence impedance and mutual impedance compensation.

The above compensations will be considered in selecting the relay.

The errors in transformation of current signals as a consequence of DC offset, or effects of remanence flux and auto reclose duty cycle on the distance relay performance will be taken into account, such that the operating time does not exceed the guaranteed relay operating time. Similarly, adequate directional function will be provided on complete collapse of the measured voltage on all type of faults.

The directional sensitivity will be maintained without increase of required operating time.

In view of induced disturbances in control and measuring signal cables (DC, CVTs and CTs) which come from the switchyard to the control room, the relay will be designed with at most stability against those disturbances. Relays connected to measure the impedance in the un-faulted phases will not operate incorrectly and give rise to unwanted tripping under very low source to line impedance ratios. The zone 3 characteristics will be offering minimum 20% discrimination against momentary maximum circuit loading conditions. Under momentary maximum circuit loading conditions, it will be assumed that voltages at the two ends differ by 10%. Power swing blocking feature will be provided in all distance relaying. However, in order to make relay system available for very slow power swings, facility for overriding the power swings blocking conditions will be provided.

The distance relay will operate for phase-earth and phase-phase faults and will have repeat contacts for interfacing with external communication channels, auto-reclose equipment, fault locator, alarms, fault recorders and remote alarm etc. Relays will be provided with hand reset type operation indicators.

Although the design will generally be suitable for under reach permissive inter-trip type, the design will also be such that protection can be switched over to co-operation of permissive over reach blocking inter-trip scheme.



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All alternatives of distance protection will be provided with blocking features due to single and three phases CVT secondary fuse failure. All alternatives of relays will be provided with facility for carrier boost. Reverse current blocking feature to securely block the tripping of the healthy line of a paralleled line section will be provided. Fail safe system against mal-operation due to failure of main components will be provided.

Power swing blocking feature for all zones will be provided. However in order to make relay system available for very slow power swings, facility for overriding the power swing blocking conditions will be provided.

The distance relay will be designed for both single pole and three pole tripping and shall have repeat contacts for interfacing with external communication channels, auto-reclose (single and three phase) equipment, fault locator, alarms, fault recorders and remote alarm etc.

Relay will be provided with hand reset type operation indicators or LED displays.

Distance protection will be provided with blocking feature due to single, double and three phase C.V.T. secondary fuse failure.

The relaying will be suitable for the communication channel in tripping, blocking or unblocking mode using built in interphase relays.

Reverse current blocking feature to securely block the tripping of the healthy line of a paralleled line section will be provided when due to tripping of end breaker of the faulty feeder of the paralleled section reversal of current in the healthy section is provided.

The relay should have suitable characteristic and accuracy for minimum fault current condition. The contractor can propose alternative protection instead of distance relay for short line after the approval of the Engineer.

In case of short and medium lengths of lines, distance relay with suitable operating characteristics will be provided to cope with large fault resistance. The setting range will be such that the short lines can be selectively protected and that are resistance compensation, R/X should be set accordingly. For extremely short line an overreaching transfer trip system should preferably be used.

Programmable microprocessor distance relays with multilateral characteristics are used widely in EHV substations. In addition to high reliability, selectivity, and sensitivity, the relays will have the following capabilities:

- Complete 4 zones, including main tripping outputs
- Very fast operating speed
- Unique polarizing system ensures fast operation even under close-up three phase fault conditions.
- Stability unaffected by CVT transient.
- High measurement accuracy with negligible transient overreach
- 24 separate measuring elements, six for each zone
- Much basic, in-built, scheme arrangement, selected by switch.
- Suitable for 3 phase or single phase tripping
- Very low voltage and current circuit burdens



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- Mutual compensation
- Optional built- in earth fault directional comparison scheme to cover high resistance faults
- Built-in voltage transformer supervision.
- Built-in power-swing blocking.
- Test capability.

a.2) Directional earth fault relay

Each line will be provided with very/normal inverse time directional earth fault relay with instantaneous unit.

The directional inverse time earth fault relay will have an instantaneous directional element which will be starting the respective over current element.

The directional relay will be polarized by open delta connected auxiliary potential transformer supplied from line CVT. The over current elements will have two units.

One high set instantaneous unit and the other unit will be directional inverse time or very inverse time.

The D.E.F. Relaying shall preferably be achieved by the use of overreach permissive transfer trip scheme using power line carrier as pilot information link between two stations.

a.3) Stub protection

The stub protection will consist of three instantaneous overcurrent relays with proper setting range. The stub protection is only activated when the line isolator is open. The stub protection will be stable for through faults owing to CT saturation or characteristic mismatching etc.

a.4) Under voltage protection

This protection will include three phase voltage sensing under voltage relays. All phases will be at a low voltage for protection to operate. In the event of a low voltage in only one or two phases, operation of the relay will be blocked after the set time and an indication will be provided. This function is necessary to avoid spurious tripping due to the removal of fuses in the measured voltage circuit. After operation of the relay, the tripping signal will be interrupted after about the set time approved by IGM Requirements & Instructions, regardless of whether or not the voltage has been reestablished.

The operation of under voltage protection will automatically be blocked when the series isolators of the transmission line have been opened, so that spurious tripping will be prevented when the line is isolated.



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a.5) Over Voltage Protection

The over voltage relaying will generally consist of definite time over voltage relay and have a setting from 100% to 120% of rated voltage and continuously adjustable time delay of 2 to 20 sec. This protection will trip the line and send inter-trip signals to the remote end. This relaying will be of single phase design.

a.6) Fault detector relays

The dual channel transfer trip scheme using audio frequency shift tones on power line carrier will provide reliable and secure high speed remote tripping of line terminals in the event of failure of a circuit breaker to clear a fault. Normally the trip and output contacts of the two receivers are connected in series to provide maximum security (prevent false trip). Each tone will be connected to a different voice channel of the power line carrier set to provide extra security. In the event of failure of a channel the "Loss of Guard" relay will operate to revert to single channel transfer trip operation. However, in order to guard against false trip due to noise during single channel operation fault detectors will be connected in series with the healthy channel to improve security. The fault detectors will consist of an impedance relay (offset mho type) for three phase faults and a negative sequence current relay for phase to phase and line to ground faults. In the event the fault detectors cannot pick up due to a low energy fault, a timer contact will bypass the fault detector contact. The timer will be operated by the healthy transfer trip receiver.

a.7) "Device (97)" Fuse Failure Protection

Fuse failure condition will be monitored by P.T. secondary voltage supervision so that following function will be initiated in the event of open circuit of one, two and three-phase fuse failures. Alarm function can't be accepted in the event of primary three-phase loss of voltage. The equipment for this function will be located in respective sub 1 & sub 2 panels or common cubicles as the case may be, thus also incorporating into this monitoring or cables from switchyard, panel fuses/MCB.s etc. for all places where only metering is provided, merely annunciation is sufficient. However, for all other location e.g.: line distance protection, transformer & reactor impedance protection, under-voltage protection, live line / dead bus & live bus-/dead line voltage check conditions etc. the fuse-failure relaying will be used to annunciate and block the respective functions from tripping by them. Apart from above, since this relaying can mal-operate under voltage unbalance conditions due to line charging and single-phase auto-reclosing conditions, the functions to bypass the impedance relay blocking from fuse failure relaying for 200 milliseconds from the instant of manual line charging and dead-time of auto-reclose relay will be provided.

a.8) "Device (94)" Trip Order Devices

Trip order devices, will be provided to trip the respective C.B.s upon operation of protection relays. These devices shall generally be of two categories, one of single and three phase type which will function during transient fault conditions and the other of three phase type functioning under permanent fault conditions. To prevent damages to the plant



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due to subsequent re-energization under permanent abnormalities, the respective C.B.s will be tripped and their lock out relay initiated.

a.9) “Device (79)” Line Auto reclosing

High speed single shot automatic reclosing relays will be provided with both single and three pole reclosing. The auto reclosing should be switch selected manually for appropriate mode of operation. When each mode has been manually selected; the distance protection should automatically select the required mode depending on the type of fault. Reclosing will be initiated on first zone tripping of distance and high speed transmission line protection, and shall automatically block for other protection where required. It shall also block manually closing on to a short circuit. Auto-reclose equipment shall operate by specified sub 1 and sub 2 protection relays.

For the lines having shunt reactor compensations, special precaution due to electro-magnetic and electro-couplings from sound phases will be considered for single phase auto reclosing.

Auto reclosing shall not take place for a time duration of 3 to 5 sec. while charging the line.

The auto reclosing by A.R. schemes shall take place for all the C.B.s in a specified manner. If they were closed at the moment of the tripping, an “open” breaker shall not be closed in the event of auto re-closer.

Provision will be made for blocking from local control and by remote control.

The A.R. scheme shall provide a hand reset lock out for permanent line faults and it shall not be possible to reclose the C.B.s once.

For number of A.R. scheme operations will be provided. The A.R. scheme will be locked for C.B. maintenance condition and limiting condition of C.B.

The relay will be equipped with the main features such as C.B. memory functions and C.V.T. voltage check and live line/dead bus. Deadline / live bus, synchronous check relay (for checking voltage, frequency and phase angle condition before closing).

The C.B. close pulse from the auto re-closer will be provided for definite time. Special features will be provided to ensure that only one close pulse will be given at the end of each dead time. The scheme monitor will be provided to lock out the scheme if it has not completed its cycle by the end of preset time (e.g.: due to necessary line/bus voltage conditions not being preset to permit reclosing). The scheme monitor timer shall have long range to accumulate maximum dead time plus maximum reclaim time setting.

b) Sub II Protection

The integrated /separated protection shall consist of following features.

1. Distance protection (21P+21NS).
2. Tele-protection scheme for distance and directional earth fault (85)
3. Power swing blocking
4. Switch on to fault



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5. Directional earth fault (67N)
6. Stub protection (50 STB)
7. Under voltage protection (27)
8. Over voltage protection (59)
9. Fuse failure supervision (97)
10. Trip function devices (94+86)

b.1) Distance Protection

The distance relay for 230kV line will meet the full performance specification as specified for the distance protection in Sub-I. However, distance relays in Sub-II will be of different design, make and type.

The zone extension type scheme will be fast, accurate and reliable distance relay having mho characteristics in R-X plane. It will be providing complete three phase, three zone, and three step distance protection for the phase and earth faults in lines.

The relay will be provided with zero sequence compensation and mutual coupling compensations (when the relaying applied to parallel lines) etc. The design of compensation will be such that the performance of distance relays of healthy lines will not be deteriorated in any respect. The relaying will be employing two sets of measuring relays one for zones 1 and 2 and other set for zone 3 and starting.

The relay will be suitable for co-operation with P.L.C system, using built in auxiliary relays etc. for its use with permissive under reach scheme. The scheme will also be suitable for blocked over reach type schemes to facilitate the relay application on very short distance lines or on special application e.g. T-OFF lines etc.

The relay will be provided with flag or LED indications etc. for various conditions including "relay circuit defective". The relay will be suitable for its application on both single phase and three phase tripping and auto re-closers etc. It will have adequate contact outputs for various functions e.g. 1 and 3 phase tripe for CBs, 1 and poly-phase fault locator, C.B.F initiation, 1 and 3 phase auto reclose initiation for CBs, 1 and poly-phase fault recording, carrier receive, carrier boost, alarms, carrier aided trips, auto reclose blocking due to carrier system.

The switched scheme will be fast, accurate and reliable distance relay having mho or rectangular characteristics in R-X plane. It will be providing complete 3 phase, 3 zone, 3 step distance protection for phase and earth faults in the lines.

Similarly when applying these relays for parallel lines, mutual coupling compensation will be provided. When mutual sequence compensation is provided the design of mutual sequence compensation will be such that the performance of distance relays of healthy lines will not be deteriorated in any respect. The relaying will be employing measuring elements and impedance type starter.



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The relay will be suitable for co-operation with PLC system using built in auxiliary relays etc. for its use with permissive under reach scheme.

b.2) Directional Earth Fault Protection

The directional inverse time earth fault protection for 230kV line will meet the full performance specification as specified in Sub-I. The protection will have a normal inverse time characteristic in accordance with IEC document 60255-4 and the required directional function.

In parallel with the inverse time function, a constant time function is requested with the primary operating value adjustable 100-200 A and time delay 5-10 s. For stabilizing the protection for inrush current when energizing transformers, both the inverse and the constant time function will be stabilized with the second harmonic. A thermal capability of 50 KA primaries for 1.0 s is requested. 230kV line sub-II protections will be provided with directional normal/very inverse time (along with high set instantaneous unit) earth fault relay. The range, accuracy, characteristics and other details of this relay will be similar to the one for Sub-I.

2.8.11 Other Protection Requirements

Permissive inter-trip will take place from the protection in sub-II via interface to teletransmission equipment in Sub-I common panel. The inter-trip will normally be of the permissive under reach type unless otherwise specified scheme.

In addition to the trip function in sub-II the distance protection, directional high speed earth fault protection will start breaker failure protection. The above relays except earth fault relay, will initiate the line auto re-closure relay.

2.8.11.1) Short Transmission Line protection

According to IGMC Requirements & Instructions for 230kv lines shorter than 10Km and 230kv lines shorter than 25km Line Differential relay with distance function should be applied as base of SUB1 protection. In this case, the basis of SUB2 protection should be distance relay with suitable tele-protection scheme such as Permissive Over reach Transfer Trip (POTT). Supplementary functions such as Weak-end infeed and current reversal function in case of parallel lines should be offered along with the tele-protection function.

It should be noticed the line differential protection includes two relays situated on two sides of the line. These relays should be of the same type.

It should be noted based on IGMC Requirements & Instructions for very short lines (less than 3 Km, the basis of SUB I and SUB II protection should be of Line Differential (87L) relays with distance functions.

Note: According to IGMC Requirements & Instructions In power plant feeders the basis of SUB I and SUB II are Differential (87L) and DOC/DEF, respectively

2.8.11.2) Power Transformer protection (where applicable)

The protection scheme for power transformers are shown on relevant protection diagrams. The salient transformer protection relays are specified below:



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a) Sub I protection

The integrated /separated protection shall consist of following features.

- 1) Differential protection (87T)
- 2) Restricted earth fault protection (87NP, 87PNS)
- 3) Under voltage protection (27)
- 4) Over voltage protection (59)
- 5) Trip order devices (94+86)
- 6) Follower relays

Device (87T) Differential Protection

The differential relay (87T) for the transformers will be percentage differential type with through fault stability and second harmonic restraint features. The differential relay will be preferably provided with 5th harmonic restrain instead of 5th harmonic blocking. It shall have three bias windings per phase having percentage bias setting range of 15% to 45% and operating setting of 10% to 20% of C.T. secondary rated current under zero-restraint conditions. Power transformers are equipped with on-load tap-changers and the relay offered will be such that there will not be any necessity of changing the setting of the relay whenever the transformer taps are changed. The relay will be of high speed type. It shall also incorporate a high set instantaneous over current element set at around eight times the rated current in each phase.

Universal type interposing current transformers in all three sides will be included for matching C.T. secondary currents. Fixed ratio interposing C.Ts shall not be preferred.

The relays will be provided with hand reset flag indicator.

Device (64 P, 64S) Restricted Earth Fault Protection

Restricted earth fault relay will be of single pole, instantaneous high speed and high impedance Voltage operated type to provided earth fault protection.

It shall have a sensitive setting to detect faults at 10% of the transformer winding from neutral. It will be tuned to supply frequency and shall remain stable for through faults.

Non-linear resistors to protect the relays from high voltages will be offered, if required. The operating time of relay shall not exceeded 25m sec. the CT's secondary connections for this protection will be done in the relay house.

Device (27) Under-Voltage Protection

An integrated three phase voltage relay to operate on under voltage conditions of 20/33kv system.

Voltage time characteristic of under voltage relay shall preferable be definite time. The trip function of this relay, but, instead via self-reset relays with heavy duty type contacts.



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Device (59+81) Over-flux protection

A three phase over flux rely may be integrated in differential protection to operate on over voltage or over flux condition. The over flux protection shall have two independent adjustable stages for alarm range from 0.1 to 1 Sec.

Voltage time characteristic of over flux protection shall preferable be of inverse type.

Follower Relays

Follower relays are necessary to multiply the signal of the transformer guard relays such as gas pressure protection, fire protection, tap changer, Buchholz relay and winding temperature.

These auxiliary relays shall have sufficient contacts for trip, alarm, recorders etc. It is essential that relay will be very quick and should be provided with operation flag indicators.

Device (86+94) Trip Order Devices

Trip order devices will be provided to trip the respective CB.s upon operation of protection relays. These devices shall generally be of two categories, one which functions during transient fault conditions and the other functions under permanent fault conditions. To prevent damages to the plant due to subsequent re-energization under permanent abnormalities the respective CB's will be tripped and its lock out relays initiated.

b) Sub II protection

The integrated /separated protection shall consist of following features.

- 1) Over current & earth fault protection (50/51-50N/51N)
- 2) Neutral over current protection
- 3) Trip order devices (94)
- 4) Follower Relays

Device (50/51) Over Current Protection and earth fault protection

The transformer protection will be provided with three phase over current relay where shown on the diagram.

The relay will be equipped with second harmonic restrain feature. This protection shall generally consist of two sub units-one having Normal and extremely inverse time characteristics in accordance with IEC document 255-4.

The other unit of the over current protection will be comprising of high set instantaneous unit.

Second harmonic stabilization feature will be provided in the relay.

Device (50/51N) Neutral Over-Current Protection



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The transformer protection will be equipped with a non-directional earth fault current protection supplied from the transformer neutral point. The protection shall have normal and extremely inverse time characteristics in accordance with IEC document 255-4. For stabilizing the earth fault current protection for inrush current when energizing the transformers second harmonic stabilization feature will be provided in the relays.

Device (86+94) Trip Order Devices

Trip order devices for sub 2 will be provided as specified in sub 1.

Follower Relays

For Buchholz and oil temperature protection follower relays as mentioned in sub 1 should be provided.

2.8.11.3) Aux./ Grounding Transformer Protection (where applicable)

The protection of auxiliary transformer will be chosen from the following relays:

“Device (51N)”

The auxiliary transformer will be equipped with earth fault current protection. The protection shall have suitable current - time characteristics in accordance with IEC 255-4.

“Device (50NS)”

Sensitive leakage current relay to detect cable and cable pothead leakage current to ground will be provided for auxiliary transformer protection.

“Device (64S)”

As section Sub 1.

“Follower Relays

Follower relays as mentioned in transformer protection for all guard relays of auxiliary transformer such as Buchholz and winding temperature etc. (if any will be provided)

2.8.11.4) Busbar protection

Busbar protection will consist of differential protection and CT supervision alarm relay.

Busbar protection will be arranged with protection zones in accordance with the principles of zone overlapping.

For the faults between CT's and circuit breaker which are within the zone of busbar protection and will not be cleared by the bus bar protection, this protection will initiate the breaker failure protection to clear this type of fault by short zone protection.

The busbar protection will be designed as a three phase protection (single element relay for each phase) to check the phase faults as well as ground faults.

The protection will be designed with a high degree of security against spurious tripping. It will not initiate tripping on maximum DC offset and maximum short circuit power on external fault.



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All busbar feeders will be isolated in the event of a fault on busbar.

The breaker failure protections of all CB's which are located in the relay panels of each feeder will be started on tripping of busbar protection.

a) Low Impedance Type Differential Busbar Protection

Based on contractual drawings and specifications and especially if CT's are not all of the same ratio or characteristics, Low impedance differential relay should be used as biased differential protection. In this scheme no stabilizing resistor and metrosil is needed and the CTs are connected directly to the relay. The protection scheme should protect all the busbars and in case of double busbar arrangements should cover check zone protection. The busbar protection relay should also cover all the feeders and the needed requirements for the future extension of the substation should be prepared by the contractor (including the extra bay units for the future feeders in distributed schemes or adequate analogue and binary inputs and outputs in central schemes).

The operating differential current and the slope of the characteristic should be settable by the user.

b) Busbar Protection C.T Supervision Alarm Relay

The busbar protection will be provided with supervision of the current transformer summation circuits during normal operation. Suitable 3 phase bus wire supervision relays will be used for each protection zone to safeguard against faults in the C.T secondary wiring.

It will be connected across AC bus wires in the relay panel and will close its contacts when the voltage appearing across the bus wires in the relay panel exceeds its relay voltage setting.

This relay will be capable of detecting loss of a partial current if this value is 5-10% of the load current in maximum loaded tapping. After being actuated the supervisory equipment will initiate an alarm after 3-5 seconds adequate time delay and actuate the C.T secondary shorting relay.

2.8.12 Fault Recorder

All IEDs will be equipped with Fault Recorder function and the data acquired by the F.R. function will be transferred to the server or any other destination designed in the DCS system through IEC61850 protocol.

The main function of recorder will be acquisition of electrical AC input quantities (voltages and currents) and DC quantities of events. These quantities to be recorded will be scanned continuously converted to a suitable digital format and filed in the pre-fault memory.

The latest scanned values shall over write the oldest in a cyclic form. By internal / external triggering, mentioned values (pre-fault) the input data and certain subsequent value (post fault) will be stored in an event memory before transferring to a display unit (printer, monitor, magnetic mass memory, etc.) or sending the information to the DCS server and HMI through IEC61850 Protocol.



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Evaluation of data stored in this way shall take place at a local point and / or separately at the central evaluation station. Fault recorder systems shall have following features:

- Self monitoring of acquisition station with fault indication and report signal.
- Event identification with year, month, day, hours, minutes, seconds, and percent of second.
- Local and central evaluation reproducible as often as required.
- Central evaluation with format selection, sectional enlargements on computer controlled output units (x/y plotter, video display, and matrix printer) with high quality presentation.

The events length to be stored will be selected within a reasonable number of seconds and adapts to the event. Further data for the evaluation are filed in the event memory for each event, such as time and date of start, cause of start, number and type of inputs, as well as length of pre-fault record. The event memory shall have capacity for a necessary number of events before transfer to the mass storage unit.

The exact moment of the fault (event) occurrence will be recorded by an internal accurate clock which indicates date and time.

2.8.13 Auto reclosing

The high speed transmission line protections, e.g. distance, will be initiating the auto reclosing. The auto reclosing will be blocked while charging the line until 3 to 5 seconds later. The auto reclosing will also be blocked under permanent fault conditions, stub protections, limiting conditions of the circuit breakers, carrier system not available or testing, reverse side H.V. equipment faults, breaker failure tripping, pole discordance tripping and any other devices which are necessary to block the auto reclosing.

The A.R. scheme will provide a hand reset lock out for permanent line faults and it will not be possible to reclose the CB's once it is decided that the fault is not of transient nature. For lines which are connected in 1.5 CB arrangements, the auto reclosing schemes will be as per type LL. Type LL is for 1.5 CB bay having two lines in each bay in which middle CB will be required to auto reclose for both line faults. The scheme will provide following manual modes of selection for sequence of operation.

2.8.14 Synchronizing Equipment

The synchronizing equipment will be used for local and remote closure of the circuit breaker.

The following circuit connections are required:

- Voltage selection for choosing the transmission line, transformer feeder and busbar voltage
- Calling circuits for the ordered synchronizing function from the control panel, remote control and automatic equipment
- Indicating circuit
- Breaker closing circuit



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- Connection of automatic equipment for synchronizing
- In DCS systems, the facilities for manual synchronization through Synchroscope, double volt-meters and frequency meters or one digital equipment should be provided in each BCR.

2.8.15 Panels and associated equipment

All panels for relays, control, meters, fault and event recorders, fault locators and interface cubicles will be constructed with back door and front glass. Protective relay panels will be of swing type. All panels, boards and boxes will be completely metal enclosed and will be dust, moisture and vermin proof.

Protection degree for outdoor and indoor cubicles will be IP54 and IP42 respectively.

Panels will be free standing, floor mounting type and will comprise rigid welded structural frames enclosed completely with cold rolled sheet steel with thickness not less than 2 mm.

The doors can readily be opened and closed and the wiring will be allocated sufficient space to be clearly and neatly arranged. Adequate cooling in the cubicles will primarily be arranged by natural circulation.

All equipment on front of panel will be mounted flush or semi flush. In case of semi flush mounting, only flange or bezel will be visible from the front. For all relative protection panels, external door with viewing glasses, in addition to equipment frame with apparatus frame and door with window for each rack will be provided.

The number of items of equipment grouped in every cubicle will be such that the various unit readily be replaced, and have adequate cooling. Terminal and wiring markings will be clearly visible. All panels will be fitted with earthing terminals of connection by copper conductor with a cross-sectional area at least 35 mm² to earthing system of the substation. The panels will be equipped with suitable devices for connecting the cable shields. The devices will be arranged so that the connection to the cable shield will be as short as possible. In addition the panel's door will be connected to main body by means of braided copper conductors.

The panels will be equipped with internal lightning with switches and with wall sockets and telephone sockets. The supply will be run to terminals to allow for connection to the lighting network of the station.

All sheet steel work will be painted in accordance with relevant standards.

Conductors will have the necessary area and construction with regard to load and mechanical strength. The panel wiring to be carried out with 450/750V grade, single core with flame, vermin & rodent proof PVC insulation. Conductors in control panel will consist of extra multi-strand single copper conductors with an area of min 1.5 mm² terminated with terminal lugs. The conductor in protection panels and for CT & CVT circuit will be extra multi-strand, single copper conductor with the following min cross - sectional areas:

- For busbar protection 1.5mm², CU
- For all other protection 1.5mm², CU
- For metering/recording 1.5mm², CU



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- For SCADA circuits 1.5mm²,CU
- For all CVT Circuits 2.5mm² ,CU
- For CT circuits 4 mm² ,CU

Cross section of wires in CT circuits (including SCADA interface) will be subject to CT burden calculation.

Maximum permissible voltage drop in 400/230 VAC circuits will be 5%.

Maximum permissible voltage drop in LVDC circuits will be 5% till the end consumer and will be less than 15% during motor starting.

For PT secondary cable the max. Allowable voltage drop is 0.5% for Instruments , statistical measurement and Debiting measurement.

Resistance of conductors must be considered at 70° C for PVC and 90° C for XLPE cable.

Outdoor marshalling cubicles will contain terminal blocks, the necessary connecting devices, internal connections, nameplates, instruction plates, auxiliary relays, switches and various items of equipment which is necessary for its respective systems.

2.9 LVAC system

Substation electrical supplies will be provided via two feeders from 6.6KV common switchgear in power plant.

Substation main LV switchgear will be supplied through two MV/LV auxiliary transformers. During detail design, if deemed appropriate by the contractor and approved by the client, the MV feeders to the substation may be deleted and replaced by two LV feeders.

Boards and switchgear cubicles will be metal enclosed, indoor type, fix type, free standing, and designed according to IEC 60298.

The low voltage AC system will comprise of indoor main and distribution boards, outdoor distribution boards and incoming feeders to main LVAC board.

The essential (emergency AC) and nonessential (normal AC) busbars of main switchboard will be fed from two incoming feeders from MV/LV transformers and one feeder from individual diesel generator or emergency feeder from power plant. These busbars will be interconnected by a section breaker.

In principle, essential and nonessential loads will be supplied by one incoming feeder from power plant and the other incoming feeder is spare (from MV), and on loss of both incoming emergency supply source (from substation DG or emergency feeder from power plant) will supply essential load and the load of nonessential section if operator so requires.

All identical equipment and corresponding parts will be fully interchangeable without having to carry out modifications.

The complete selection scheme will have both automatic and manual changeovers.

The outdoor and indoor distribution and lighting boards will receive power from essential and nonessential sections of LVAC switchboard and distribute the AC supply in respective area.



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The height of indoor boards will be 2200 mm and cable entrance will be from bottom with gland plate.

Busbars will be made of copper and PVC sleeved and bus taps and joints will be PVC shrouded.

Busbars will be adequately supported and braced to withstand the stresses due to the specified short circuit currents for the associated switchgear.

Busbar supports will be made of insulator materials or special molded plastic material with electrical and mechanical withstand.

Separate supports will be provided for busbar of each phase. If a common support is provided for the busbars anti tracking barriers will be provided.

Busbar joints will be of the bolted type and busbars will be thoroughly cleaned galvanized at, the joint locations and suitable contact grease will be applied just before making a joint.

2.10 LVDC System

The DC supply system for 230kV substations will comprise of two sets of battery charger, two main DC distributions busbars, two DC distribution boards, one set emergency lighting board, two battery sets and complete set of accessories, control switches to provide full transfer between chargers, batteries, main busbars and DC distribution boards.

The battery will be suitable for operation on equalizing and floating charge system a capable of providing the guaranteed output throughout the range of ambient conditions specified.

The batteries will be specifically designed for the switchyard functions including heavy-duty switchgear control, telecommunication functions. It is required that the ratings of battery will be adequate to supply the 100% load.

Each battery shall comprise a sufficient number of cells to provide the rating specified

The battery charger will be capable of float charging the battery from the AC supply voltage specified. Facilities will be provided for equalizing charge of the battery cells as well.

The battery charger will be sized to supply required dc current to the connected load and recharge a fully discharged battery in the specified time. It shall maintain the battery on proper float charge after the recharge. It is required that the ratings of battery charger will be adequate to supply the 100% load.

The charger output current will be sufficient to return the battery to full charge in 10 hours after a 8 hour discharge rate, with rated discharge current corresponding to rated discharge time. Meanwhile the charger will be capable of supplying the normal service current.

2.11 Cables

The size and type of the cables will be so selected that does not exceed the limiting temperature and current carrying capacity specified by IEC standards for site condition.

For selecting cables the following factors will be considered:



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- Continuous current carrying capacity by considering the feeder permissible over loads
- Short circuit capacity
- Voltage drop

Table 1 below states the maximum permissible continuous and transient conductor temperature for various types of cable insulation.

Table 1. Maximum permissible temperature for cable insulation

Type of cable Insulation	Maximum permissible continuous temperature (°C)	Maximum permissible transient conductor temperature(°C)
XLPE	90	250
PVC	70	160

The Contractor is responsible for mutual compatibility and adequacy of all cable system and all other corresponding equipment, in any respect.

Cables will be color coded as follows:

- For phase conductors : red, yellow and blue
- For AC neutrals and other connections : black
- For ground connections : yellow/green
- For DC circuits : gray

A common system of cable numbering will be used throughout the plant. All cables shall have a unique number and the cores within that cable shall bear the same number such that they may be easily identified after the cables have been terminated.

The conductors will be circular plain annealed stranded copper conforming to class 2 of IEC 60228.

All Low Voltage power and control cables will be provided with fire retardant P.V.C. insulation.

In multi core cables, the interstices between the cores will be filled with suitable material compatible with insulation and operating temperature of the cables.

For CT and VT cables the metallic sheath will be supplied. It may be copper wires or tape.



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The bedding under armor will be extruded or lapped layer of PVC or synthetic tapes.

For all cables armor will be considered during the construction. For multi core cables the armor will be galvanized round steel wire supplemented by a helix tape to keep the armor wire tight. But for single core cables the armor will be made of non-magnetic material.

All cable jackets will be self-extinguishing and non-hydroscopic and suitably protected against oxidation and ultra violet rays.

All single phase power cables shall have 1 full sized conductors plus 1 earth continuity conductor which is ampere rated not less than 100% of the phase conductor.

All three phase power cables shall have 3 full size conductors plus 1 earth continuity conductor which is rated not less than 58% of the phase conductor.

The size of control cables shall not be less than the following:

- 2.5 mm² for control and protection cables
- 4.0 mm² for current and voltage transformer secondary circuits.

At each voltage level the size of conductors will be such that the maximum voltage drop shall be:

- Maximum permissible voltage drop in 400/230 VAC circuits will be 5%.
- Maximum permissible voltage drop in LVDC circuits will be 5% till the end consumer and will be less than 15% during motor starting.
- For PT secondary cable the max. Allowable voltage drop is 0.5% for Instruments and statistical measurement and 0.1% for Debiting measurement.

Resistance of conductors must be considered at 70° C for PVC and 90° C for XLPE cable.

All cables will be installed on trays, ladders, in ducts, cleated to steelworks, laid in concrete trenches.

Cable trays shall not sag more than 0.5 cm at the midpoint between supports when the tray has been loaded with cables.

Cable trays where used will be fabricated from hot dip galvanized steel.

Maximum intervals between cable trays supports will be 1.5 meters.

When laying cables the radii should not be smaller than the given by the manufacturer or 15 times the cables diameter. Also minimum installation temperature recommended by the manufacturer will be considered.

All power and control cable feeders will be of a single length with no splicing jointing.



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All cable boxes will be of adequate proportions and designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

Cable glands will be suitable for the type of cable to which they are fitted.

All cables will be identified with an approved plastic or Aluminum marker at each end of the cables. Cable cores will be ferruled with the same number at each end.

All wirings will be marked, except for conductors between terminals on a given item of equipment.

2.12 Lighting system

This section covers the requirements of the substation outdoor lighting. The outdoor lighting will be designed in accordance with the requirements of IEC lighting handbook (5th Edition), DIN 5035 and ANSI A85.1 standards. All references publications listed within the above references shall also apply. Basic design data will be as indicated in LIGHTING Table.

The design of the general area lighting will be such as to permit personnel to move about freely and safely in the substation at night without portable lamp. Separate and independent outdoor lighting systems will be designed for each switchyard area.

For the horizontal illumination of the switchyard and the vertical illumination of the power transformers, reactors, circuit breakers and disconnecting switches, the point by point method of calculation will be used.

Control of switchyard and access roads lighting both normal and emergency, will be by push-button controlled contactors. Push-buttons will be installed in the control building, at entrances to switchyard and at the main distribution board.

All the lighting fixtures will be of die-cast Aluminum, low brightness and of tropical design. Lamp socket will be mogul, multiple and porcelain enclosed. It shall permit easy, full adjustability in order to obtain I, II and III IES types of distribution with the same refractors. The refractor holder-door will be Aluminum die-cast, hinged to the luminaries housing in a manner allowing easy removal of complete assembly. The refractor will be securely held by means of a single action quick-release latch. A positive acting spring loaded latch shall permit single-glove handed release and closing of the door with a snap action.

The ballast will be constant wattage type.

The terminal board will be moulded plastic with clamp-type pressure terminals to accommodate 4 mm² wire.

Lead lighting:

- A limited number of luminaires will be used as lead lighting and shall be fed by a separate, independent circuit.
- Lead lighting will be switched on and off by photo cells. (With possible overriding of photo-cell action from the control room).



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- Lead lighting shall give an illumination level of approximately 25% of the normal levels specified above.
- Lead lighting will be installed near transformers along the central road and beside station service boards.

The outdoor lighting system will be complete with distribution boards, and frames, push-buttons, switches, etc, complete.

- The average ratings and characteristics of the OUTDOOR LIGHTING:

- Type of lamp.	High pressure sodium.
- Lamp efficiency	100 Lm/W
- Switchyard.	20 Lux
- Access roads	20 Lux
- Fence	20 Lux
- Outside of fence (20m)	20 Lux
- Vertical surfaces of main equipment's	20 Lux
- Main entrance	110 Lux
- Transformer & reactor area	40 Lux
- Uniformity factor, max. To min. less than	4
- Utilization factor not less than	0.8
- Maintenance factor	0.8
- Reflector	cut-off

2.13 Standby diesel generator (where applicable)

One Standby diesel generator 400V will be provided. The units will be capable of supplying essential (emergency AC) loads of the substation, would automatically start on the lack of normal supply to the emergency switchgear and feed all necessary emergency load of substation.

The standby diesel generator set shall come with a diesel engine directly coupled to an alternator mounted on a steel frame structure with skids and necessary dampers and floor anchors.

The standby diesel generator will be equipped with its own safety isolation disconnecting switch placed adjacent to the unit. All the necessary safety interlocks for electrical or mechanical maintenance of the diesel set will be provided.

Emergency stop pushbutton shall located close by the diesel generator switch. This switch shall immediately shut down the set. It will be lockable in stop position.

The driving unit shall consist of a direct injection, water cooled. Cooling will be effected by means of attached cooling radiators for air / water cooling plus fans. The engine may be



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required to run for extended period of time during maintenance. The engine will be directly connected to the generator.

The set will be provided with battery complete with battery charger. There will be sufficient battery capacity for at least 30 s of continual starting attempts. The battery preferably mounted on the set with dust cover.

The generator will be 3 phase and brushless, synchronous generator for 400 V, 50 Hz, 1500 rpm. Insulation will be class F and cooling mode will be IC 01 in accordance with IEC Publication 34. It will be Y-connected (star) with six (6) terminals and neutral directly grounded, and shall withstand both overload and direct short circuit at the output terminals. The generator shall have an integral AC exciter with rotating rectifier and static voltage regulator.

Daily fuel tank which will be supplied under this contract and its capacity shall be sufficient for 8 hours full load running.

For emergency diesel generator a separate building will be built.

2.14 Substation Auxiliary transformer (where applicable)

The auxiliary transformer will be three-phase oil-immersed self-cooled, designed either as free standing outdoor unit or as a metal enclosed unit with cable entrances. The transformer shall deliver its full rated capacity under the conditions of ambient air temperature and altitudes and other condition of site.

The auxiliary transformers will be used to provide low voltage to supply the station service AC supply.

The auxiliary transformers will be capable of withstanding without damage the thermal and dynamic effects of three and two phase short circuits and single line-to-ground faults for all terminals with specified system fault levels and in accordance with IEC publication 60076-5.

The auxiliary transformer shall mechanically withstand solid line to ground fault on the low voltage terminals with fault contributions from the high voltage only.

All current carrying components such as bushing, tap changers and connection shall have a minimum rated load carrying capacity equal to 120% of that of the associated winding under all service condition.

The design will be such as to reduce to a minimum the development of acidity in insulating oil. All materials will be new and of the best quality and of the class most suitable for working under the condition specified and shall withstand the variations of atmospheric temperature and condition arising under working conditions without distortion, deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

The auxiliary transformer shall comply with the provisions of this specification relating to the main transformer wherever these are applicable.

Overloading

IEC 60076-7 will be applied.



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Core

The design of magnetic circuit will be such as to provide static discharge envelopment of short circuit paths within itself or to the earthed clamping structure and the production of flux components at right angles to the plane of the laminations are flat and the finally assembled core is free from distortion.

Laminations will be of cold-rolled, grain oriented silicon steel. Each lamination will be insulated with a material that will not deteriorate due to pressure and the action of hot oil. If the joint is of the butt type and a layer of insulating material is inserted in the joint, a non-magnetic metallic connection will be made from each limb to each yoke, and means will be provided for preventing movement of the yokes relative to the limbs.

The design and manufacture of the transformer and auxiliary plant will be such that the noise level is a minimum and that the level of vibration dose not adversely affects any clamping or produce excessive stress in any material.

The cores, framework, clamping arrangements and general structure of the transformers will be capable of withstanding any shocks to which they may be subjected during transport, installation and service.

Windings

In the design, construction and treatment of winding proper consideration will be given to all factor of service such as dielectric and mechanical strength of insulation, coil characteristics, uniform electrostatic flux distribution, minimum dielectric losses, minimum restriction for free oil circulation for uniform low operating temperature, elimination of hot spots, voltage distribution between adjacent turns and throughout the winding, prevention of corona formation at normal operating voltages, and the control of dielectric flux under impulse condition for high impulse strength. The loading capabilities as indicated in this specification and the IEC standards for transformers shall apply with respect to life, maintenance and other factors affecting the operation of transformers.

Tank

The transformer tank will be a steel case of substantial construction, which will be oil tight and provided with an oil cover. The cover will be bolted and sealed to the case by means of suitable flanges, sufficient properly spaced bolts and gaskets. Gaskets between metal surfaces will be set in grooves or held in position by retainers so arranged that all parts are bolted metal to metal.

The transformer will be provided with suitable eyebolts and/or lugs for lifting the completely assembled transformer. Lifting lug and attachments shall have ample factor of safety to allow for possible unequalized lifting forces. Suitable guides will be provided inside each tank for guiding the cores and windings as they are being removed from or lowered into the tank.

The transformer tank will be capable of withstanding, without leakage or distortion, an internal gas pressure of 1.0 kg/cm². The transformer will be shipped filled with oil.

The transformer will be provided with suitable steel base to support the transformer and prevent the tank from bearing on the support pad.



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Fixing method on foundation to prevent damage due to all atonal forces such as earthquake, etc will be suggested by manufacture and all facilities such as anchoring bottling will be in scope of supply guide drawing to design foundation detail will be provided.

The transformer tank shall have an earth terminal clamp sufficient for 240mm² cu-wire on two opposite side.

The transformer tank will be provided with a pressure relief device of adequate size to protect the tank against an explosion due to arcing below the surface of the oil. The relief device will be designed so as to minimize discharge of oil and to exclude air and water after it opens.

Transformer oil

The oil will be refined mineral oil. It will be clear and completely free from solid particles, and shall not give a positive result when tested on corrosive sulphur in accordance with IEC 60296.

The oil will be uninhabited type. The oil must be pure virgin of Naphthenic base petroleum product.

The design, and materials and processes used in the construction of the transformer will be such as to reduce to a minimum the risk of the development of acidity or other deterioration of the oil.

Before delivery, a test certificate will be submitted for approval. The test certificate shall contain results for test carried out in order to proof quality of the oil.

Bushing

The transformer shall have leads brought through porcelain bushings best suited for the voltage of the lead, with a high factor of safety. Bushings of like voltage will be interchangeable between units. All bushings will be so designed that there will be no stressing of any parts due to temperature changes and adequate means will be provided to accommodate conductor expansion. All porcelain used in the bushings will be manufactured by the wet process and will be homogeneous, free from laminations, cavities or other flaws affecting its mechanical strength or dielectric quality and will be well-vitrified, tough and impervious to moisture. The glazing of the porcelain parts will be free from imperfections, such as blisters and burns.

If specified in Data Sheet Table, cable box housing the bushings will be provided.

Tap-Changers

The transformer will be equipped with a manually operated tap changer for changing connections to the taps in the high voltage windings. Taps will be changed only when the transformer is de-energized. The tap changer control will be located above oil level and accessible through the tank cover. An external operating handle, a position indicator and provision for locking in any operating position will be provided.

Conservator



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A conservator tank will be mounted in extension of the side of the cover to handle expansion of heated oil contained in the main transformer tank and cooling system. The conservator will be equipped with the following.

- 1) A bellows or other expansion device so that the oil does not come into contact with the air.
- 2) A bug-proof dehydrating-type breather connected to the conservator tank and located approximately 1.5m above the base.
- 3) A filling valve.
- 4) A drain valve.
- 5) An oil level gauge mounted on one end with markings to show minimum, maximum and 20°C oil level.
- 6) A handhole for inspection and cleaning.

Signaling

Following functions will be provided for indication and alarm/trip:

ITEM	FUNCTION
1	AUX. TRANS BUCHHOLZ RELAY TRIP
2	AUX. TRANS OIL TEMPERATURE HIGH TRIP
3	AUX. TRANS PRESSURE RELIEF VALVE TRIP
4	AUX. TRANS MECHANICAL PROTECTION TRIP
5	AUX. TRANS BUCHHOLZ RELAY ALARM
6	AUX. TRANS OIL TEMPERATURE HIGH ALARM
7	AUX. TRANS OIL LEVEL ALARM

Control housing

Large enough control housing will be provided for the termination of all control and auxiliary circuits. It will be weather proof (IP55) and insect-proof and complete with all gaskets. Thermostatically controlled anti-condensation heater and removable gland plate over cable entries shall also be provided.

TABLE 1: RATINGS AND CHARACTERISTICS OF AUXILIARY TRANSFORMER

ITEM	DESCRIPTION	UNIT	TECHNICAL REQUIREMENTS
1	Installation (Indoor/Outdoor)		Outdoor
2	Type (Core or Shell)		Core type
3	Rated frequency	Hz	50
4	Nominal service voltage of windings	kV	As Per SLD



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5	Short circuit impedance between main and secondary winding at 75 °C	%	5
6	Method of terminal connections (Air bushing or cable boxes):		
6.1	HV terminals		Cable box
6.2	LV terminals		Cable box
7	External secondary load (at site condition)	kVA	250 (Min)
8	Whether wheels are required	Yes/No	Yes
9	Phase connections – IEC vector group symbols		Dyn11
10	Whether manual off circuit tap changer is required	Yes/No	Yes
11	Off circuit tap changer		
11.1	Location		HV winding
11.2	Total range		$\pm 5\%$ ($\pm 2 \times 2.5\%$)
12	Max. Temp rise at rated power		As Per IEC 60076-2
13	Type of cooling		ONAN
14	Minimum external creepage distance	mm/kV	According to the very heavy condition
15	Oil (acc. to IEC 60296)		Non-inhibited / Naphthenic
16	Accessories		
16.1	Oil level gauge	Yes/No	Yes
16.2	Oil temperature indicator	Yes/No	Yes
16.3	Winding temperature indicator	Yes/No	Yes
16.4	Pressure relief device	Yes/No	Yes
16.5	Buchholz relay	Yes/No	Yes

2.15 DC/AC Inverter

For supplying critical AC loads AC safe system incorporation with DC/ AC inverter will be provided. During normal operation these loads must be supplied from main essential AC board when main and auxiliary AC power is interrupted. These loads will be automatically switched over to the DC/AC inverter. Inverter will be supplied from main 110 V DC switchboards and its output must be single phase 220 V, having small distortion and frequency of 50 Hz. Suitable filters will be used to obtain correct sinusoidal wave in output.



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Inverter output voltage must remain constant regardless of variation of load and input voltage. Input filter will be used to reduce AC component of the source.

2.16 Inspection and Tests

Perform all inspection, routine tests and type test stipulated in IEC standards and requirement & instructions issued by TAVANIR/IGMC at the time of signing the contract, to ensure that material and workmanship conform to the specification and drawings.

2.17 Earthing

The substation grounding system will be designed principally in accordance with the IEEE Standard No. 80 - 2000 (Guide for safety in AC Substation Grounding) and the requirements of this specification.

The grounding system will be so designed as to keep the step and touch voltages within acceptable limits, thereby ensuring safety to the personnel.

Substation ground grid will be designed to obtain a station ground resistance of less than 1Ω.

The grounding grid will take the form of a combination of buried conductor and ground rods. The conductors will be laid in parallel lines.

The grounding grid will be effectively protected against corrosion.

The conductor for connections between structures, equipment etc., and main grid will be of stranded soft drawn annealed copper.

Every steel structure that carries insulators or apparatus will be connected to the ground grid. To ensure contact even if a connection fails or a cable is cut off, every structure will be connected via two different risers to two different parts of the grounding grid.

Steel structures with more than one leg will be connected with the two risers from different legs.

Steel structures will not be used as parts of the protective earth connection of apparatus.

The fence will be connected to the grounding grid at a number of intervals. All corner fence posts will also be connected to the grounding grid.

Grounding for high frequency coupling equipment, lightning arresters and neutral terminals of the transformers will be via a ground rod of approved dimensions, driven directly in the ground at a position immediately adjacent to the equipment being grounded in addition to the normal ground connection.

All underground connections will be made through the exothermic welding procedure or equivalent.



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No bolted clamps will be used for underground connection.

Connections between risers and steel structures will be made by pressed cable lugs with two holes in the contact pad. These connectors will be tin-coated copper.

Item	Description	Technical Particulars	Unit
1	3-phase symmetrical fault current	As per SLD	kA
2	Duration of fault current	As per SLD	Sec.
3	Duration of shock current	0.5	Sec.
4	Surface layer thickness	15	Cm
5	Surface layer resistivity	3000	Ω .m
6	Depth of ground grid conductors	0.5	m
7	Assumption for calculation of step and touch voltages: a) step length b) body weight	1 70	m kg

Note: Miscellaneous system such as AC-DC UPS, lighting, cables and cableways and so on, will be considered according to the related power plant technical specifications. also. With considering of related IGMC requirements & instructions.



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3. Electrical System Data

a.) General

1- Nominal service voltage	230 kV rms.
2- Max. System voltage	245 kV rms.
3- System earthing	Solid
4- Rated frequency	50 Hz
5- 3-phase short circuit & earth fault current:	
5.1. Rated value	As per SLD
5.2. Dynamic value	2.5 × Rated value
5.3. Rated duration	As per SLD
6- Max radio interference level measured at 1.1 rated system voltage at 1 MHz	2500 mic. V
7- Voltage below which corona will not be visible	180 kV
8- Pollution level	31 mm/kV

b.) Insulation Levels (At IEC Condition)

1- Nominal system voltage	230 kV rms.
2- Rated lightning impulse withstand Voltage	1050kV _{peak}
3- Rated 1 min. power frequency withstand voltage	460kVrms
4- Rated switching impulse with Stand voltage	N.A.
5- Min. external insulation creepage distance	31 mm/kV
6- Phase-to-Phase insulation level	Acc. to IEC 60071

c.) Electrical & Safety Clearances

1- Min. clearance from ground level to the base of insulation	2.5 m
2- Min. safety clearance between live metal and positions to which access is permissible with other equipment alive	4.5 m
3- Phase spacing, center line to center line	4.5 m
4- Phase to phase (Rod. Cond)	2.6 m
5- Phase to earth (Rod. Structure)	1.9 m



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d.) Station Services Aux. AC Supply

1- Rated low voltage	230/400 V
2- Voltage variation	±10 %
3- Phase	3 (4wire)
4- Frequency	50 Hz
5- Continuous rating of bus, incoming feeders and CB's	specified by engineer
6- Short circuit current and duration of short circuit	25KA/1sec
7- Type of CB for incoming	MCCB
8- Type of outgoing feeders	MCCB/MCB
9- Neutral earthing	Solid
10-Panel finishing colour	RAL7035

e.) Stations Service Main DC Supply

1- Rated voltage	110/V
2- Type	Lead Acid(Opzs)
3- Voltage variation	-15% up to +10%
4- Wires	2
5- Earthing	Un-earthed positive
6- Battery backup time	8 hours
7- Panel finishing color	RAL7035

f.) Stations Service 48 DC Supply

1- Rated voltage	48 V
2- Type	Lead Acid(Opzs)
3- Voltage variation	-15% up to +10%
4- Wires	2
5- Earthing	positive earth
6- Battery backup time	12 hours
7- Panel finishing color	RAL7035

g.) Low Voltage Power Cable

1- Voltage designation	0.6/1 KV
2- Conductor material	(Al/Cu) Cu



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- | | |
|--|--|
| 3- Type of conductor | Stranded |
| 4- Type of insulation | P.V.C |
| 5- Type of armor and material | Galvanized steel wire for multicore cables and aluminum strip for single core cables |
| 6- Type of sheath material | Extruded P.V.C |
| 7- High voltage test | KV 3.5 |
| 8- conductor short circuit withstand current/time KA/sec | */1 |
| 9- armor short circuit withstand current/time KA/sec | */0.5 |

* will be specified by engineer

h.) Control And Protection Cables

- | | |
|--|-----------------------|
| 1- Voltage grade | 0.6/1 KV |
| 2- Conductor material (Al/Cu) | Cu |
| 3- Type of conductor | Stranded |
| 4- Type of insulation | P.V.C |
| 5- Inner insulation | Extruded P.V.C |
| 6- Type of shield (only for CT and VT CABLE) | copper |
| 7- Outer insulation around sheath | Extruded P.V.C |
| 8- Type of armor and material | Galvanized steel wire |
| 9- Type of sheath material | Extruded P.V.C |
| 10- High voltage test | KV 3.5 |
| 11- Conductor short circuit withstand current/time KA/sec | */1 |
| 12- Metal sheath short circuit withstand current/time KA/sec | */0.5 |
| 13- Armor short circuit withstand current/time KA/sec | */0.5 |

* will be specified by engineer

i.) standby Diesel Generator



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1- Rating		Acc. To Scope
2- Rated voltage & variation	V rms.	230/400+/-%5
3- Rated frequency	Hz	50
4- phases	No	3
5- Power factor		0.8
6- alternator & generator protection class		IP 23
7- Short time over speed	%	120
8- Maximum steady state change in voltage for instantaneous load increase from zero to full load and decrease from full load to zero	%	± 2.5
9- Maximum steady state change in speed form full load to no load or from no load to foul load	%	± 5
10- Maximum steady state change in frequency	%	± 2.5
11- Fuel(equivalent or better than fuel)		Acc. to IEC 34 -BS 5000-VDE 0530- BS 649
12- Round per minute	R.P.M	1500
13- Rated of voltage regulation	%	+/-%5
14- Overload capability of D.G. set	%	10



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4. Substation Control System

4.1 Definitions:

In the following sections the hereunder acronyms stand for:

BCPU: Bay Control and Protection Unit

BCU: Bay Control Unit

SCS: Substation Control System

LCP: Local Control Panel

LDC: Load Dispatch Center

HMI: Human Machine Interface

4.2 General

This section specifies the requirements for a substation control scheme. It describes the facilities required to provide the control of plant and systems within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

The SCS system shall comprise dual station computer system with data acquisition, processing and storage facilities, with interfaces for users to interact with data, based on a distributed architecture.

Local area networks shall interconnect computing devices and peripherals, and optical fiber cables shall interconnect with BCUs/BCPUs.

The system shall manage the data and provide the system operation functions specified in other parts of this specification. The system shall comprise proven hardware and software.

The SCS will be suitable for operation and monitoring of the substation.

In principle, the monitoring and control of the substations will be provided from four different levels, including:

- | | |
|----------|--|
| Level 1: | Local level: control from the local control panels (LCPs) or backup mimic control panel (if any required) associated with the switchgear |
| Level 2: | Bay level: control from the SCS bay units located in the bay Control room. |
| Level 3: | Station level: control from the SCS central work station in the substation control room |
| Level 4: | SCADA level: Supervisory/ control from the load dispatch center by means of SCADA system via gateway. |



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The SCS supplier shall demonstrate that the system proposed has been designed, installed and commissioned in accordance with the relevant international standards and the specification.

4.3 System Functional requirements.

4.3.1 General

The substation control system provides complete monitoring and control facilities for the whole substation. This is usually referred to as the substation plant “Remote” control location, since the operator workstations are remote from the primary plant.

4.3.2 Modes of operation

The operator workstation shall have the following operational modes, each password protected:

Monitoring	Ability to select graphic displays and lists for viewing only. No capability to acknowledge alarms, controls or select item for inclusion in program functions.
Control	Selection of graphic displays and lists. Able to acknowledge SCS alarms and complete controls of the substation.
SCS Engineering	Provides all the SCS monitoring functions, together with online facilities for program/database/format modifications and checking.

In addition a facility to provide access to the numerical protection relay and fault recorder data (also the facility to alter relay settings and access to the analysis software) will be provided.

A series of passwords will be personally assigned to operators in each of the above categories.

It will be possible for substation operators to log on to either of the substation workstations, and to be allocated the appropriate mode of operation relevant to the password. SCS engineering work and access to protection relay and disturbance recorder data shall generally be carried out at the engineering workstation.

All workstations and the system database shall function as a unified system. It shall not be necessary for example, to acknowledge an alarm at more than one workstation.

Similarly, an operator manual entry applied at a workstation will be immediately displayed at other workstations where this data is presented.

The same protocol should preferably be used for communication between main server, BCU and protection relays.



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4.3.3 HMI Displays

4.3.3.1 General Requirements

The format of all displays shall contain a system window area/bar, used for communications between the operator and the SCS system. This window shall in general not be resized.

In case two displays are connected to each HMI workstation, the cursor shall move from one operator display to the second display without separate selection of display in use.

Displays may consist of more than one page, in which case it will be possible to carry out paging by on screen selection for page forward, page back.

The system shall provide a single line diagram display of the substation, on a single page. Separate page for each voltage level and/or individual bays shall also be provided, with paging between the overview page, voltage level pages, and individual bay page displays.

The workstation shall provide multiple window interactive display facilities. Multiple picture windows will be capable of display on the screen at the same time. Windows will be locked and applied only for HMI operation.

The selection of displays will be carried out by a combination of the use the keyboard pointing device, keys, and menus.

4.3.3.2 System Window Area

This shall include the following:

The menu bar- this bar shall contain pull down menus for miscellaneous local and external functions e.g. perform picture selection, create a new window etc.

The alarm icon-this field shall indicate any unacknowledged alarms in the system, and shall also be typically used for calling up the alarm window. The icon shall always be present on the screen when there is an unacknowledged alarm in the SCS system.

The system clock-the data and item will be presented in the format DD-MM-YY, HH-MM-SS.

The dynamic function keys field-this field shall display the dynamic function keys applicable to the picture currently on display.

4.3.3.3 Use of color

All displays shall preferably have a gray or other dark background. Proposals for the use of color on all displays may be considered (for improved visibility, printing, etc.) and will be finalized during the implementation phase of the project.

4.3.3.4 Power Flow Announcement



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Power flow direction shall conform to the following:

- active and reactive power flowing into the substation is an import
- active and reactive power flowing out of the substation is an export

In tables, lists and reports an import will be shown as a negative.

4.4 HMI Functions.

4.4.1 Event processing

All events shall have a date and time tag appended, to a resolution of 1ms. Events will be displayed in chronological order.

Events will be immediately stored to disc as they occur

4.4.2 Alarm Processing

Selection of the alarm list will result in the latest page being displayed, preferably with new alarms added to the top of the list. An alarm list on display will automatically be updated with new alarms as they occur.

Substation alarms shall include two levels of alarm priority on the lists. The allocation of alarms to a priority level and the use of color for each level (also for SCS alarms) will be finalized during the implementation phase of the project.

An alarm will be raised as the full capacity of computer storage drive.

4.4.3 Analogue Measurement Handling

Analogue quantities will be reported to the SCS system whenever the analogue value deviates from its last known value by a predetermined threshold. New values will be stored in the real time database and any limit value violations will be passed to the alarm handling routines.

The system will provide for the storage of half hourly averages of all measured and calculated analogues (based on values in the database approximately every 20 seconds). Weekly, monthly and annual statistics, showing the peak demand with time and data for each period considered, will be included. The calculation of average values will be possible even if certain instantaneous values are missing, manually input etc. 15 months storage will be provided.

The system will also record half hourly values of the integrated demand in MWh and MVARh. Weekly, monthly and annual energy statistics, showing the peak demand with time and data for each period considered, will be included. 15 months storage will be provided. This will be calculated in the SCS system from the half hourly averages of MW and MVAR.

4.5 Measuring Unit

Measuring center will be digital, suitable to be used in HV substations (feeders) and capable of measuring true RMS, per phase and total for the followings:



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- 4.9.1 Voltage line-to-neutral and line-to-line for each phase and average of all phases.
- 4.9.2 Current of each phase
- 4.9.3 Active Power of all three phases.
- 4.9.4 Reactive Power of all three phases.
- 4.9.5 Apparent Power of all three phases.
- 4.9.6 Active Energy imported, exported
- 4.9.7 Reactive Energy imported, exported
- 4.9.8 Power factor of all three phases
- 4.9.9 Frequency

Watt - hour - meters and VAR- hour meters will be suitable for measurement of loads in three phase, three wire circuits. They will be suitable for semi-flush mounting on vertical panels with only flanges projecting outside with back connected terminals.

Meters will be suitable for operation from the secondary's of C.T.s. and V.T.s. They will be provided with separate 3 phase, 4 wire type test blocks without disturbing the C.T. and V.T. connections.

Number of digits provided for energy metering will be adequate to cover 1000 hours of operation.

Meters will have a continuous overload capacity of 200% for accuracy as well as thermal limits. Also it shall withstand 10 times rated current for 3 sec. without loss of accuracy.

Accuracy specification for Kwh shall comply with IEC 687 class 0.5. All other parameters will have a minimum Accuracy of 1 percent of full scale.

4.6 Controls

Control of substation plant will be effected from the individual bay single line diagrams.

The method of man machine dialogue will be a multi-stage procedure with software and hardware verification at each stage to ensure security of control. Verification of control selection at a BCU/BCPU will be included before a control is allowed to proceed.

It shall not be possible to make two control selections at a BCU/BCPU simultaneously, and a BCU/BCPU shall only be controlled from one workstation (or the load Dispatch Center) at a time.

The function of a control system is to collect all the information for the operations personnel to supervise the operating conditions of the substation and whenever necessary to initiate changes to operating conditions.

The substation will be equipped with operating and acknowledgement system for all circuit breakers (CB) and disconnecting switches (DS, ES). Control of operation will be possible from control room (central or bay), locally from switchgear, and remotely from dispatching center (SCADA).

Two modes of operation in HMI will be available for selection:

- SUB/SCADA IN SUB.: In this mode, in SCADA only indication is possible, while complete control and indication is possible in SUBSTATION.



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- SUB/SCADA IN SCADA.: In this mode, in SUBSTATION only indication will be possible, while complete control and indication is possible in SCADA.

For selection of the two above modes, two push buttons will be designed on the HMI for control of substation. Indication from the above selected positions will be transferred to SCADA.

Each circuit breaker and isolator will be provided with indication in control room.

Depending upon type of C.B. mechanism various indicating conditions of C.B will be indicated/ annunciated in control room.

4.7 Logging

4.7.1 Event Logging

A chronological record of all events is to be output to the event printer. It will be possible for a substation operator to enable/disable event logging.

4.7.2 Scheduled Logging

The operator will be able to configure logs for printing on the color printer. The printing schedule will be adjustable from a single interval to repetitive intervals.

4.7.3 Page Logging

With any page on display at a workstation it will be possible for the substation operator or SCS system engineer, by simple keyboard/mouse action, to arrange for a print of the display on the color printer.

4.7.4 Historical Data

Facilities will be provided to periodically store historical data on hard disk of computer, for long term storage. This means of storage will be capable of being reloaded back into the system as required.

4.8 Graphical Displays

It will be possible to display a real time trend of any system analogue. 10 displays will be provided. The display will consist of a graphical representation of the analogue quantity continuously updated in real time. The sampling rate will be operator selectable, with a minimum period of 10 seconds.

4.9 Fault Incident Records

Facilities will be provided to compile and store fault incident records. Where appropriate a fault incident will be initiated from an alarm list entry.

4.10 Interlocking

The interlocking function shall provide for operation of circuit breakers, disconnectors and earth switches only when certain conditions are fulfilled. It is required to be distributed so that it does not depend on a central function. Communication between the various bays



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for the station interlocking shall take place via the optical fiber communications subsystem.

Interlock conditions inhibiting control of a plant item will be clearly indicated to the operator. Full details will be readily selectable.

4.11 Synchro-check

A Synchronizing check feature will be provided for circuit breakers that may have voltage, frequency and phase differences outside the limits acceptable for closing.

Provision shall also be made for overriding the check synchronizing facility, from an SCS workstation and also from the SCADA control center(s)

4.12 Communication with protection Relays and Fault Recorder

The SCS will be equipped with suitable interfaces, communications protocols and analysis software compatible with the protection relays and fault recorders (if existed) .

This data will be presented at the Engineer's workstation computer. Such data shall generally be transferred over the system LANs as low priority data.

Fault/event record files will be automatically uploaded to the SCS, so that data is not lost when the relay is reset.

4.13 Dynamic Coloring

The dynamic colouring function shall provide colouring of the single-line diagram process picture.

The aim of dynamic coloring function will be to give the operator a quick overview of the actual connection topology state of the switchgear or the entire network. The operator will be able at one glance, to tell whether each segment is earthed, energized, or de energized.

4.14 SCS Hardware and software

The system shall comprise proven hardware and software, requiring the minimum of development work. If either hardware or software is required to be developed for this project, then this will be identified in the tender together with an estimate of the work required.

4.15 SCS Master System

The function of the master system is to organize and control all the functions of the plant and the SCS equipment. It can be considered as comprising the following:

- Station Computers



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•Peripherals

Database information will be common to the all operator workstations. Data manually entered by an operator at a workstation will be automatically passed to other workstations. Similarly for alarm acknowledgement and safety tags etc.

It shall not be necessary to reselect any display for updating of real time data to be completed.

The hardware envisaged is as follows:

4.15.1 Station Computers

The station computers will be based on real time industrial strength equipment, DC/AC powered, commercially available and will be provided with a real time multi-tasking operating system. Personal computers and/or personal computer operating system are not acceptable.

4.15.2 Laptop Workstation

The laptop workstation with windows and relays software.

4.15.3 Master clock

A time standard will be provided to all the station equipment. An intrinsically accurate master clock equipped with a radio receiving terminal capable of receiving a time signal from the Global Positioning satellite system will be provided. GPS signal shall not be fed into system via station computers. The master clock will be automatically corrected by the received time signal. The master clock shall provide timing information to the SCS system, the protection relays, fault recorders and any other plant equipment including a reference time. The timing information will be connected through suitable interface connectors to synchronize the timing sources.

The master clock shall have a stability of 1millisecond per day.

The GPS receiver shall receive and extend to the master clock an indication of UT from the full range of NAVSTAR satellites.

4.16 Communications with Bay Units and Load Dispatch Center

4.16.1 General

The on line station computer shall handle the data acquisition communication tasks to the bay units and form an interface between the bay unit communications subsystem and the station operator workstations (also the LDC system) etc. A single station computer fault



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shall not cause loss of communications to any bay unit. Encoding, decoding, and checking of data validity and miscellaneous communications timings will be completed in the station computer.

Peer to peer communications signaling, providing a Client Server architecture will be provided over the communication protocol. Cyclic transmissions from the BCUs/BCPUs, also event initiated transmissions, are acceptable. A polled/master – slave mechanism is a non – preferred arrangement.

4.16.2 Message Structure and Security

- (a) The station server shall support IEC 61850 protocol.
During the implementation of the contract full details of all the physical link and application layers of the protocol will be submitted to the Engineer for approval.
- (b) Communications messages will incorporate error control mechanisms for error detection and recovery. Message Validation will be an additional checking mechanism to message error detection and recovery. Message validation shall verify the correctness of the data received at each transaction to identify invalid data. Superseded messages will be detected and rejected, so that operator actions and data are not reverted due to transposed messages.
- (c) Transmission of controls from the SCS or the Load Dispatch Center control center to the BCUs/BCPUs will include messages to increase the security of controls.
- (d) Communications system failure to a BCU/BCP shall not result in loss of data.
Local data storage facilities will be provided as necessary.

4.16.3 Communication With Load Dispatch Centre

- (a) Communication interfaces for signaling to the Load Dispatch Center (L.D.C.) for the SCADA system will be provided. In case of independent LDC's for different voltage levels at substation gateway will be considered.
- (b) The system shall provide for communication to/from remote control center/RTU via IEC 60870-5-101,.
- (c) The SCS shall fully emulate the functionality of the new SCADA manufacturer's RTU to the LDC. The SCADA system is being separately specified under the Load Dispatch Centre, and the SCS supplier will be responsible for liaising with the SCADA manufacturer. Any protocol licensing required etc. will be the responsibility of the SCS contractor.



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- (d) Selective and/or “Grouped” data, acquired by the station computer from the bay units, will be passed to the Load Dispatch Centre. Remote control of certain items of plant will be managed by the SCS system. The SCS shall manage the data required to be exchanged with the Load Dispatch Centre at such a rate as to satisfy SCADA/ response times established for existing stations.

4.16.4 .Communications Circuits

To provide high immunity to noise and electrical isolation between areas of the plant fiber optic communications will be provided between each bay unit and the station computers. For integrity and high system availability the optical paths will be dual redundant.

4.16.5 Gateway

Interfacing with upper SCADA-system will be done by the gateway. Remote control center(s) must be able to control the whole substation via the gateway. The remote control center must be able to do control functions and monitoring tasks via the gateway.

The gateway system will transmit commands from SCADA to the substation control system in addition to information exchange between them.

If the gateway is not include in server computer, an external gateway will be considered.

4.17 BCUs/BCPUs

4.17.1 General

A BCU/BCPU will be provided for each bay (or Cut-off) separately. The distributed backup control mimic will be installed next to the bay control unit which can be used in case of maintenance or emergency or if BCU fails. Local bay control via the back-up control mimic on the control and protection cubicles shall incorporate the same user safety measure e.g. bay interlocking, synchro-check, etc.

The SCS software and BCUs must be supplied from same manufacture.

BCUs/BCPUs will be equipped for the delivered I/O, plus 15% spare capacity.

4.17.2 Design

- (a) Each BCU/BCPU shall include interface to the real time LAN.
- (b) BCPUs shall provide both control and protection functions, each function being a separate independent element within the unit.
- (c) Control messages from the station computer/the Load Dispatch Center, will be capable of being initiated at any time to control the plant, and shall have priority over all other messages.



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(d) BCUs/BCPUs will regularly receive synchronizing signals from the GPS/Master clock to maintain to accuracy of time tagging not exceeding 2 ms, with a resolution of 1 ms.

(e) Input/output Facilities

4.18 Data from switchgear, etc. will be hardwired to the BCU/BCPU I/O modules

4.19 System Software

All softwares will be original (with serial number) and issued in the name of client.

4.19.1 Operating System & SCS Software

- The computer operating system will be independent of the hardware configuration and application, it will be a standard system and shall not be modified by the SCS manufacturer.
- It will be the responsibility of the Contractor to obtain any licenses required for the operation of the software.

4.19.2 Communication Software

- The communication protocol between the SCS and the Load Dispatch Centre will be responsibility of contractors

4.20 Spares and Test Equipment

The following is additional to the project general requirements:

Spares shall include a minimum of one of each type of module supplied under this section of the project. Functionally compatible Spares will be made available for about 15 years from the commissioning date of the SCS.

Test equipment will include PCB extender boards and special items of test equipment required for maintenance of the SCS.

4.21 Training

The following is additional to the Specification general requirements for training.

Factory training will be allowed for the Client's technical staff who will maintain the SCS equipment.

Site training shall include SCS familiarization for the Client's substation staff, who will operate the SCS at the substation. This familiarization course will be repeated a minimum of four times to allow for adequate number of staff to attend.



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5. Telecommunication System for tele protection system

5.1. Power Line Carriers(PLC)

PLC shall mean a communication system used to convey tele protection signals between power utility installations, utilizing HV power transmission line conductors. Power line carrier terminal line equipment shall mean the equipment in a PLC system which transmits and receives signals to and from the PLC line coupling equipment and operating at least between 40 and 400 KHZ. Line coupling equipment of power line carrier system, shall mean the combination of coaxial cable, line tuning units, coupling capacitors and line traps required to couple the signals to/from the PLC terminal equipment to / from the HV power transmission line conductors.

5.2.1. Standards

Work of this section shall comply with the requirements of latest edition of NEMA, IEEE, ANSI, ITU-T, BS, DIN, IEC 60495, IEC 60834-1 and IEC60489-9.

5.2.2. Design

The PLC system will be used for tele protection signaling transmission. Each of the contractors supplied PLC links shall provide at least 99.9% reliability.

The PLC equipment required on this project shall be:

SSB terminals for protection with a nominal occupied bandwidth of 4 KHZ in each direction of transmission. Teleprotection tones can be above speech or within speech bandwidth.

The PLC terminal equipment shall have the following features:

- (a) PLC terminals will be equipped with the super audio channel will be used for teleprotection signals.
- (b) Boost trip will be provided for use with the teleprotection tone-relaying scheme, if required.

5.2.3. Detailed Data

Each Power Line Carrier link shall provide a duplex communication channel between two terminals of a high voltage transmission line. The Power Line Carrier equipment will be all solid state with a latest technology, employ single side band suppressed carrier operation with a nominal occupied bandwidth of 4 KHZ in each direction of transmission.

- Transmission power 20W/40W
- Power supply Variation 48 VDC -15% +20%



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- Line impedance 50, 75, 125 (D) (unbalanced)
125,150 (D) (balanced)
- Return loss line >12 dB
- Programmable frequency (Tx, Rx) 40~400 KHZ
- Transmission band of 4KHZ
- Signaling programmable ON/OFF or FSK
- Asynchronous data transmission 50,100,200,600,1200, BPS
- Synchronous data transmission QPSK
- Modulation Bit rate 1200/2400 BPS QAM
- Modulation Bit rate 4800, 9600BPS
- -Data interface RS.232, ITU-T, V.24/EIA
- Universal call converter should be provided
- Analog interface for selective teleprotection.
- Accessories for PLC
- Extension card
- Service telephone,

Ambient Temperature

The PLC equipment will be operated with no deterioration in performance with respect to site climatic data's, See also section 2- General requirements.

5.2. Tele protection Signaling System(TPS)

Teleprotection Signaling Equipment shall mean the equipment, comprising an audio frequency transmitter, and audio frequency receiver and associated logic equipment for transmission of teleprotection signals, over a voice frequency (VF) channel. Teleprotection equipment must be capable of providing the signaling for three modes of operation stage, acceleration (permissive intertripping) blocking and direct intertripping including circuit breaker failure (C.B.F).

- The teleprotection must be in form of "4 command version" and with guard signal. Each teleprotection signaling equipment will be capable of recording and storing with time stamp the transmitted and received command and events.



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6. Mechanical System

6.1. Heating, Ventilation and Air Conditioning

This section covers the following systems:

- Heating
- Ventilation
- Air conditioning

The HVAC system will be provided for the following purposes:

- To provide a comfortable working environment within the building for personnel and equipment
- To temper the incoming outside air during winter to prevent freeze-up problems
- To maintain sufficient air circulation within the building to ensure that heat losses from the equipment do not result in an excessively uneven temperature distribution

6.1.1. Basis Of Design

The work shall include the required combination of the following:

- Ventilation fans
- Exhaust and natural ventilator fans where necessary
- Explosion proof exhaust fan
- Side wall fans (if applicable)
- Grills, registers and diffusers
- Louver & sand trap
- Wall mounted air conditioners
- split type air conditioning units
- Electric heater where necessary
- Gas or electric water heater where necessary
- Thermal insulation
- All associated piping, valves, hangers and supports
- All associated instrumentation and controls
- Associated electric works
- Associated structural steel work and civil works

6.1.1.1. Applicable Codes and Standards and related documents

In accordance with the latest relevant and internationally recognized codes and standards, such as ASME or as listed in the "ASHRAE HANDBOOKS", latest edition.

6.1.1.2. Design Criteria

Outdoor design conditions during summer and winter will be determined according to the relevant site conditions.

Indoor design condition and minimum requirements for HVAC system of different buildings, which one applicable are indicated in, below table.



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Building or Enclosure	Part of Bldg.	Indoor Design Condition			Type of System	Equipment	Ventilation ⁽²⁾		Pressurization
		Relative Humidity	Summer Temperature	Winter Temperature ⁽¹⁾			Area Fraction according to ASHRAE 62.1	People Fraction according to ASHRAE 62.1 (CFM/person)	
BCR/CCR	Switchgear area	T=22±2°C	T=24±2°C	No Control	HVAC	Split type room air conditioner (cooling/heating) + Radiator(if required) ⁽⁵⁾	1 ACH for infiltration		Equal
	Battery area (if applicable)	T>=15°C	T<=30°C	No Control	HVAC	Explosion Proof Exhaust fan + Inlet air through sand trap, packaged unit or transfer air from adjacent area	For Hydrogen Dilution to 2 percent of room volume		Negative
Common Area In any Building (if applicable)	All Locker Rooms	T = 22±2 °C	No Control	No Control	HV	0.5	-		Negative
	All Pantries	T = 22±2 °C	No Control	No Control	HV	0.3	0		Negative
	All Showers	T = 30±2 °C	No Control	No Control	HV	50 CFM/Unit			Negative
	All Lavatories	T = 15±2 °C	No Control	No Control	V	70 CFM/Unit			Negative

Note1:

- 1) Room average temperature
- 2) The designer shall use architectural plans to estimate the number of people who are present in each space, as well as calculating its area, and the amount of ventilation shall be finalized in the detailed design.
- 3) Type of unit heaters and radiators are electric and will be finalized in detail design.

Note 2:

- HVAC system refers to Heating, Ventilation and Air Conditioning
- R.H refers to Relative Humidity
- HV refers to Heating and Ventilation
- V system refers to Ventilation
- Electric heating will be used in remote areas or in cases where electric heating is more practical proposition.
- Electrical water heater will provide required domestic hot water

6.1.2. System Configuration



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6.1.2.1. Heating System

HVAC system for containers shall be finalized by package vendor.

Heating will be provided to ensure uniform heating of the area where necessary or applicable.

6.1.2.2. Ventilation System

Exhaust fans shall be provided for ventilation of battery rooms and other areas where extract fan will be used.

Fresh air of the building shall be provided through louvers, and these louvers could be adjusted manually to control the amount of airflow.

Complete ventilation systems will be provided for the areas as stipulated depending on the type of system, supply or exhaust fan, ductwork with grills, air intake, exhaust air louvers, sand trap, manual damper, fire dampers(fusible) and sound attenuates will be provided where necessary.

The battery rooms will be ventilated adequately and this air will be extracted with two explosion-proof exhaust fans (one as 100% redundancy).

Exhaust fans pull odors, fumes, and moisture from an area of the required zone, venting them outdoors for removal. The fan uses a motor to turn its blades, which function to pull air out of the space. The stale, humid, or contaminated air is propelled through the exhaust fan through the exiting required zone.

6.1.2.3. Air Conditioning System

Operation of split air conditioner (heating/cooling) is as follows:

Liquid refrigerant, after passing through the expansion valve, evaporates in the coil. The evaporation process cools the warm air blowing over the coil. The cooled air then enters the zone, which is to be conditioned.

The heated refrigerant liquid from evaporator flows towards the compressor. There, the liquid is compressed and converts to vapor. Compressed vapor refrigerant then flows to the condenser coil to exchange heat with the outside air and converts to compressed liquid. The liquid refrigerant then passes through the expansion valve and the cycle is repeated as explained above.

6.2. Fire Fighting

Fire protection will be provided in all parts of the substation will consist of fire of portable and mobile wheeled extinguishers.

6.2.1. Basis Of Design

6.2.1.1. Applicable Codes and Standards

This system will be designed and constructed in conformity with the following codes and standards or equivalent international codes.



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- NFPA 850: Electric Generating Plants
- NFPA 10: Portable Extinguishers
- NFPA 72: Fire alarm & detection systems
- NFPA170: Standard for Fire Safety Symbols

6.2.1.2. Design Philosophy

The aim is to provide the structural and process-related fire protection measures to minimize loss of life or serious injury and preventing the spread of a probable fire. In this regard all areas of the substation will be subdivided into fire zones and sub-zones each suitably equipped with the proper fire detection and firefighting equipment to suit the risks involve.

The philosophy for fires is to extinguish them in the early stages if possible and thus to minimize the damage and financial loss caused by an incident. Extinguishing will be achieved with portables for small hydrocarbon fires, mobile or fixed equipment for pool fires in bunds, portable carbon dioxide extinguisher for electrical fires.

6.2.2. Description Of Fire Fighting Systems

The fire protection system will comprise of Portable fire extinguishers. Portable extinguishers are intended as a first line of defense to cope with fires of limited size. They are needed even if the property is equipped with automatic sprinklers.

Portable extinguishers should be selected and installed according to condition, size, type temperature and classification of fire and hazards. Classification of hazards are as follows:

- Light (low) hazard: These are locations where the total amount of class "A" combustible materials is of minor. Like offices, classrooms, halls, etc.
- Ordinary (moderate) hazard: These are locations where the total amount of class A combustibles and class B flammables are present in greater amounts than expected under light (low) hazard occupancies, like light manufacturing, workshop and allied storage.
- Extra (high) hazard: These are locations where the total amount of class "A" combustibles and class "B" flammable, like aircraft and boat servicing, storage and manufacturing processes such as painting, flammable liquid handling.

Considering mentioned criteria for this project portable extinguishers are considered as following:

- Dry powder type for electrical/ordinary fire
- Carbon dioxide for electrical fire

Also wheeled extinguishers of above mentioned types may be used where it is necessary.

7. Civil



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7.1. Description

Switchyard structures shall mean galvanized steel structures the support of electrical equipment. Buildings structures is painted (not need galvanized).

Work of this section includes: design, manufacture, testing, transportation and supervision over installation and erection of switchyard structures and their all accessories.

The work described in this section covers the structural steel and anchor bolts for the following cases:

- Support structures for disconnect switches, switch operating mechanisms, current transformer, voltage transformers, lightning arresters, line traps (according to switchyard layout drawing) and post insulators.
- Portal structures (Gantries) for overhead conductors in long spans.

The work also covers steel mounting rails and pedestals for mounting of the equipment.

The work also covers shackles of the substation structures to terminate the transmission line insulator strings.

7.2. Terminology

Technical terminology is to be as defined in latest edition of IEC 50, IEEE 100 and ASTM standards.

7.3. Standards

Work of this section shall comply with the requirements of latest edition of “BS, DIN, AISC, ACI, AWS, ASTM, JIS, ISO and Iranian National Building Code” standards. which ACI, AISC & DIN standards are preferred.

It is noteworthy that special publications related to high voltage structures design and behavior could be referred e.g .:

- VDE 0210 - Regulations for the construction of overhead power lines above 1kV
- IEEE STD 693 - IEEE recommended practice for seismic design of substation
- ASCE manuals and reports on engineering practice No.52 - Guide for design of steel transmission towers.

7.4. Design



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7.4.1. Design Criteria

7.4.1.1. General

The contractor is totally responsible for mutual compatibility and adequacy of all buildings and switchyard structures and all other corresponding equipment, in any respect.

7.4.1.2. Loading

Loading of buildings is according to "Iranian National Building Code, part: 6" & 2800.

Switchyard Structures shall be designed on the basis of loads described in the following paragraphs, applied both to the structures itself and attached or supported accessories. These loads are working values without overload factor.

a) V= Vertical Load

Dead load of equipment, conductor and support structure

b) N= Normal load for suspension conductors

The structure shall be designed such that each conductor or shield wire will have characteristics not exceeding the following :

(i) Substation bus

- phase conductor tension according to sag-tension calculation
- shield wire tension according to sag-tension calculation
- Horizontal angle (from normal to girder) 0 deg.
- Vertical angle (from horizontal) ± 5 deg.

(ii) Termination of the Transmission Lines

The structures which accept the transmission line conductors and shield wire shall be designed on the following assumptions:

- Phase conductor tension according to table no. 1 of this section.
- Shield wire tension according to table no. 1 of this section .
- Horizontal angle (from normal) $\square 35$ deg.
- Vertical angle (from horizontal) $\square 20$ deg.
- These loads must applied in load combination no.2 (LC2) acc. to 9.4.1.3 .

c) I = ICE loading

The thickness of ice coating must be considered as table no.1 in section 2 (general requirements) of specification.

The density of the ice is assumed to be 900 kg/m³

d) W = Wind Load

Wind forces shall be taken as follows :



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Vw = Velocity of wind (maximum for 5 sec) given in table no. 1 in section 2 of specification .

C = Drag factor

Depending on shape, wind load is assumed to transverse or longitudinal

Other way of obtaining loads due to wind is referring to "Iranian National Building Code, part: 6" & considering wind velocity & all related factors for loading and design .

e) S = Short Circuit Load

Short circuit forces shall be taken as resulting from an electrical fault as specified in section 1 (summary of work) being applied to the conductors and current carrying parts of equipment being supported.

A flexible conductor subjected to short circuit will have a tensile force in the direction of the conductor, and a rigid conductor (tube) a force transverse to it .

f) E = Earthquake load

Earthquake forces shall be taken as follows :

$E_h = A_e \times B_e \times W_e$ horizontal component

A_e = Seismic factor

obtained from standard elastic response spectra

B_e = Amplification factor

W_e = weight

The Earthquake load is assumed to be transverse or longitudinal and upward or downward

It is noteworthy that forces due to stretching of cables in earthquake (due to horizontal deflection of two neighboring apparatus and influence of this deflection on tensions) should be considered .

g) M = Maintenance and Erection load

Each member whose longitudinal axis makes an angle less than 30 degrees with the horizontal shall be of sufficient section to withstand a concentrated load of 150 kg. (independent of all other loading) applied vertically to the longitudinal axis at any point along its length .

(h) Temperature

The ambient temperature data is specified in site condition.

7.4.1.3. Loading Combinations

The structure shall be capable of withstanding the forces resulting from the following loading combinations :

(LC1) Normal wind with ice



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$M + V$

$N1$ = Conductor tension

Ice on conductor, temperature for ice load = 0 C

$W1$ = Wind load for ice condition

for wind velocity = 25 m/s

(LC2) High wind without ice

V

$N2$ = Conductor tension

No ice on conductor,

20 C above minimum ambient temperature

$W2$ = Full wind load

for maximum wind velocity

(LC3) Short circuit with wind

V

S = short circuit load

temperature at short circuit circumstances no ice on conductor

$W3$ = wind load for short circuit

$W3 = 0.49 \times W2$

(LC4) Earthquake

V

$N2$ (refer to LC2)

$E4$ = Full earthquake load

for maximum horizontal ground acceleration

No short circuit loads

No ice on conductor

(LC5) short circuit with earthquake

V

S (refer to LC3)

$E5$ = Earthquake load in short circuit condition

$E5 = 0.6 \times E4$

No ice on conductor

7.4.1.4. Safety Factor



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All structures shall be designed with the safety factor on working stress recommended in mentioned standards and not less than the following :

type of members	permissible load based upon	minimum safety factor for load combination	
		without earthquake and/or short-circuit	with earthquake and/or short-circuit
tension	yield strength	1.5	1.1
compression	buckling	according to related standards	

7.4.1.5. Unit Stresses

a) General

All parts of the structures shall be designed so that the unit stresses in members and connections produced by the most critical combination of the specified design loads considering appropriate safety factors, do so not exceed the relevant values according to mentioned standards .

Members and accessories shall be of such size, shape and length as to preclude damage or failure from vibration or stress reversal or fatigue

b) Secondary members

Secondary members, without calculated stresses, shall be designed for a force resulting from 2.5 % of the axial load in the member being restrained .

c) Stresses

The contractor shall use one of stress formulas in applicable standards for proportioning the structure members to withstand the following stresses :

- Compression
- Tension
- Bending
- Shear
- Bearing

However, member allowable stresses (as outlined above) in excess of the limiting allowable values, given in the DIN & AISC standards, shall not be accepted .

d) Buckling

All kinds of buckling (e.g. torsional buckling, local buckling) should be considered.

7.4.1.6. Slenderness Ratios



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The maximum ratio of unbraced or unsupported length (L) measured between working points on the design drawing to the least radius of gyration R of a member (L/R)

- Structure leg member and girder chord members	120
- Other members having calculated stress	180
- Redundant or secondary members without calculated stress	240

7.4.1.7. Deflection

The following deflection limits for columns and girders shall be limited to the following :

- (i) Girders supporting disconnect switches - 1/300 of span, vertically and horizontally .
- (ii) All other girders - 1/200 of span vertically and horizontally .
- (iii) Columns - 1/200 of the total height at the top.

7.4.1.8. Material

Steel

The main material of the steel switchyard is angle or double angle .

The following steel grades shall be used for construction:

The material of hot-rolled structural shapes, plates, angles and bars construction is exclusively grade S235JR according to DIN EN 10025-2 and ST37-2 grade according to DIN 17100(Old Germany code), details are Persian section.

The material of hot-rolled structural shapes, angles plates and bars construction are exclusively A36 according to ASTM.

		A36
Yield strength	F_y [MPa] =	240
Tensile strength	F_u [MPa] =	370
Young's modulus	E [MPa] =	210,000
Poisson's ratio	ν [-] =	0.3
Shear modulus	G [MPa] =	81,000
Density	γ [kN/m ³] =	78.5

Bolts

The bolts are available as grade A325

The available diameters are: M12, M16, M20, M22, M24, M27, M30 and M36

		A325
Yield strength	F_y [MPa] =	640
Tensile strength	F_u [MPa] =	800



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All bolts should be protected against corrosion according to the indications made by the producer.

If possible A325 bolts should be used.

Concrete

The concrete foundation and buildings for standard cylindrical Specimen are in grade C30.

7.5. Fabrication And Manufacture

7.5.1. Minimum Sizes

The minimum thickness, before galvanizing of structure legs and girder chords and all foundation members shall not be less than five millimeters (5mm) and all other members not less than three millimeters (3mm). The width to thickness ratio, "b/t", of any angle leg shall in no case exceed than limits given in used standards in which "b" is the longest leg measured from the end of the root fillet to the extreme fiber and "t" is the nominal leg thickness .

Minimum thickness of gusset plates shall be 6.0 mm

The minimum width of the connected leg of an angle shall be related to the diameter of the bolt being used and shall be twice the diameter plus 12.0 mm .

The minimum diameter of connection bolt shall be 12mm .

If more than one diameter of bolt is used on the contract, irrespective of quantity, the minimum variation in nominal diameter shall be 4 mm.

7.5.2. Splices and Bolted Connections

All field connections shall be bolted, and the shank of all bolts shall extend full size completely through the connected members .

Use of gusset plates should be kept to a minimum .

Where angles are lap spliced, the heel of the inside angle shall be chamfered to clear the fillet of the outside angle .

The minimum bolt pitch, minimum edge distance measured from the center of the bolt hole to any edge shall be in accordance with used standards .

Splices shall develop the maximum stresses in members with no credit given for abutting joints. the number of splices shall be the minimum practicable .

End connection of angle members shall be detailed in such a manner that blocking or flattening the outstanding leg is not required .

Splices should be as close as possible to a node point. In vertical or sloping members lap splices shall be above the closest node point .

The minimum length of lap splice from leading to trailing bolt in angle lap splices shall be twice the flange width of the smaller lapped member. The location of the bolts in lap splices shall be such that the center of gravity of the bolt group is as close as practicable to the center of gravity of the combined member in the splice.

7.5.3. Excess



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All anchor bolts, bolts, nuts, ring fills and lock washers shall be furnished in excess of the actual number required, in quantity sufficient to compensate for normal field losses. The excess quantities shall be at least ten percent (10%) greater than the actual requirements.

7.5.4. Double Angle Members

All double - angle members shall be connected at intervals between end connections by stitch bolts. The spacing of stitch bolts shall not be more than 0.9 meter for tension members. For compression members, the spacing shall be such that the L/R ratio of one angle between stitch bolts will not be greater than the L/R ratio of the whole member and not more than 0.6m.

All double angle members shall be connected in at least 2 points between panel points. Angles with connected legs longer than 100 mm shall be connected with 2 stitch bolts end filler plate at each point (one bolt on each gauge line). Angles with connected legs 100 mm or smaller shall be connected at each point by one bolt and ring fill which shall be placed on the inner gauge line.

7.5.5. Marking

All pieces shall be distinctively marked with erection marks, clearly visible after galvanizing, corresponding to those on the erection drawings. Steel stamping dies, minimum 16 mm high, shall be used and special care shall be taken to see that all erection marks are made in such a manner as not to be obliterated in transit, or in any way damage the galvanizing or impair the strength of the member.

7.5.6. Welding

The use of welded connections shall be kept to a minimum; when necessary, welding of steel shall be carried out before galvanizing in accordance with mentioned code for arc and gas welding in building construction.

7.5.7. Drilling and Punching

Drilled or punched holes are acceptable for material up to 12.5 mm thickness. Material over 12.5 mm thickness shall be drilled or sub-punched and reamed. All burrs left by the drill or punch shall be removed completely .

Before galvanizing steel members, bolt holes shall not be more than 1.5 mm (one point five millimeters) larger in diameter than the diameter of the bolts .

Allowance shall be made in gauge dimensions on steel members for the thickness of subsequent galvanizing and the possible formation of spelter fillets inside the angles so as to allow adequate erection clearance after galvanizing .

Holes shall be accurately placed so that, except for tension members, no “drifting” will be necessary at site to enable assembly.

7.5.8. Bending

All bending of pieces should be done cold. However, hot bending where advisable shall be specified on the drawings .

Bending shall be done in such a manner that the full section shall be maintained and so that the physical properties of the steel will not be impaired. Approval by Engineer shall be obtained for any bending by cutting and welding.



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7.5.9. Galvanizing

All steel used in the construction of the structures shall be galvanized after all manufacture is completed .

Galvanizing of all material shall be in accordance with ASTM A123 for structural sections and ASTM A153 for small accessories. Galvanizing shall be applied by the hot - dip process. The zinc coating shall be smooth, clean of uniform thickness and free from defects .

The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material. Tests shall be carried out in accordance with article 9.4.3 source quality control .

Note: All other similar process shall not be used.

7.6. Supervision Over Installation and Erection

Perform visual inspection before installation to ensure that there is no damage.

Ascertain with Engineer that all concrete foundations have cured for the minimum period specified, and that all back fill is compacted to its approved level before placing or erecting structural steel on the foundations.

Inspect all structures accompanied by Engineer prior to the equipment erection operation. Notify Engineer four (4) weeks before the structures are ready to be inspected.