

**Annexure- II of Addendum No. 3 (Vol-2) (Item 16- Electrical):
for sub-clause 6.9.5 Technical Specification- Electrical**

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1. 11 KV PANEL/ SWITCHGEAR

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1.1 Applicable Standards

The 11 KV HT Panel and its components shall conform to the latest applicable standards specified below:

Sr. No.	Code No.	Title
1.	IS 13118 / BS 5311 / IEC 56, 694	Specification for High Voltage AC Circuit Breakers
2.	IS 3427 / BSEN60298 / IEC298	AC Metal enclosed switchgear and control gear for rated voltages above 1 KV and up to and including 52 KV
3.	IS 2705 / BS 7626	Current Transformers
4.	IS 3156/BS 7625/IEC 186	Voltage Transformers
5.	IS 5578	Guide for marking of insulated conductors
6.	IS 2544 / BS 3297 / IEC 273	Busbar Support insulators
7.	IS 3231, 3842 / BS 142 / IEC 255	Electrical Relays for Power system protection
8.	IS 1248 / BS 89 / IEC 51	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories
9.	IS 9385 / BS 2692 / IEC 282	High Voltage Fuses
10.	IS 722, 8530 / BS 5685 / IEC 145, 211	Specification for AC Electricity Meters
11.	IS 6005 / BS 3189	Code of practice for phosphating of iron and steel
12.	IS 9920 / IEC 129, 265 & 298	High Voltage Switches
13.	IS 13703 / BS 1362 / IEC 269	Low voltage fuses
14.	IS 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
15.	IS 6875 / BSEN 60947 / IEC 947	Control Switches

1.2 Constructional Features

The 11 KV HT Panel shall have separate compartments, according to definition in the Standards, for the following components:

Each set of bus bars, Current transformers, Voltage transformers on incomer side, Each main switching device, Cable chambers suitable for heat shrinkable type cable termination, Metering, control, indications, annunciations and relaying devices.

Switchgear shall comprise indoor, metal-clad, draw out type Vacuum/SF6 circuit breaker. The circuit breaker shall be fully horizontally draw out type. The circuit breaker shall have distinct 'service' and 'test' positions. In the 'test' position, the circuit breakers shall be capable of being tested for operation without energizing the power circuits. Adequate number of auxiliary contacts shall be provided for each of the 'service' and 'test' limit position switches.

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The 'test' position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing. The switchgear shall fully house the breaker both in the 'service' position as well as in the 'test' position. The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.

Instruments, relays and control devices shall be mounted flush on hinged door of the metering compartment located in the front portion of cubicle. All auxiliary relays not requiring manual resetting will be mounted inside the Low Voltage compartment.

1.3 Safety Interlocks

Switchgear shall be provided with following interlocks:

- Operation of an isolator shall not be possible unless the associated circuit breaker is in the 'open' position.
- Compartment door of a breaker or an isolator shall not open unless the associated breaker or an isolator is in 'open' position.
- Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.
- It shall not be possible to rack-out/withdraw a 'Closed' breaker from 'Service' position to 'Test' position or rack-in a 'Closed' breaker from 'Test' position to 'Service' position.
- The breaker trolley/cassette shall be earthed firmly before the same gets into 'Service' position.

1.4 Fabrication

Metal enclosure shall comprise rigid welded structural frame enclosed completely by metal sheets, minimum 2.5 mm thick, hot rolled (HR) or 2.0 mm thick, cold rolled, cold annealed (CRCA), smooth finished, levelled and free from flaws.

All sheet steelwork shall be phosphated in accordance with the following procedure and in accordance with relevant standards for phosphating iron and steel.

- Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.
- Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- After phosphating, thorough rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying.
- The phosphate coating shall be sealed by application of two coats of primer suitable for finishing by powder coating.
- After application of the primer, the fabricated sheet steelwork shall be subject to epoxy based powder coating. Shade of powder coating is subject to approval by the Employer's Representative.

The final finished thickness of the coating on steel shall not be less than 100 microns and shall not be more than 150 microns.

Each floor-mounted, free-standing panel shall be provided with its own base channel of at least 50 mm height, providing rigidity to the entire assembly. The base channel may be painted matt black. Panel door shall be supported by strong hinges and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All the hardware such as nuts and bolts shall be of stainless steel.

All doors, panels, removable covers shall be gasketed all around with neoprene gaskets. All louvers shall have screens and filters. Vent openings shall be covered by fine mesh on

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the vertical face. The screens and grills shall be made of either brass or galvanized iron wire mesh.

Separate removable gland plates with minimum thickness of 3 mm shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material. Structure, buses and control wiring troughs shall be so designed and arranged as to make future extensions readily feasible. Lifting lugs shall be provided for installation purposes.

1.5 Bus bars

Main bus bars shall be of electrical grade aluminium of high conductivity and non-segregated type. Bus bars shall be located in air insulated enclosures and segregated from all other compartments of the cubicle. Direct access or accidental contact with bus bars and primary connections shall not be possible. To provide a seal between adjacent cubicles, bus bars shall be taken through FRP seal-off barriers.

All bus bars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections is required, suitable bimetallic connectors or clamps shall be used or copper shall be tinned to prevent electrolytic corrosion. Bus bars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings as specified. Maximum temperature of the bus bars and bus bar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 85 deg. C.

Bus bars shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current. Bus bar support insulators shall conform to relevant standards. Supports shall be of porcelain, cast resin, DMC or SMC. Hylam or similar hygroscopic material shall not be used for bus bar supports or shrouds. The bus bar clearances in air shall be suitable for the Basic Insulation Level (BIL) of the equipment and the bracing shall be suitable for electrodynamic forces during short circuit.

Bus bars shall not be normally painted and all performance characteristics specified shall be obtained with unpainted bus bars. Bus bars shall be insulated by heat shrinkable type sleeving providing full insulation, with mould caps protecting all joints. 'Raychem' or equivalent make sleeving providing full insulation shall be provided.

1.6 Circuit Breakers

a. General

Circuit breakers shall be VCB or SF6 type. These shall conform to relevant standards specified and shall be of draw out type. Circuit breakers shall comprise three separate identical single pole units operated through a common shaft by the operating mechanism. Circuit breakers shall be suitable for switching duty of transformers.

Isolating plugs and sockets for power as well as control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced and shall be insulated with PVC or other insulating material shrouds.

The vacuum circuit breakers controlling motors shall be complete with surge arrestors to provide protection against switching surges. Breaker internal wiring up to the plug shall be similar for all breakers.

b. Operating Mechanism

Circuit breaker shall be power operated, by a motor charged spring operated mechanism. Main poles of the breakers shall be such that the maximum difference between instants of contacts touching during closing shall not exceed half cycle of rated frequency. Operating mechanism shall be provided with anti-pumping feature, electrically and mechanically. Electrical anti-pumping feature shall be obtained by means of an auxiliary relay.

Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker is already closed, failure of any auxiliary spring shall not cause damage to the circuit breaker or endanger the operator. A mechanical indicator shall be provided to show 'open', 'closed', 'service' and 'test' positions of breaker. It shall be located in a position where it will be visible to the operator standing on the front of the switchgear with cubicle door closed.

The closing coil shall operate correctly at all values of voltage between 80 % and 110 % of the rated voltage. A shunt trip shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and all values of supply voltage between 50 % and 110 % of rated voltage.

Mechanical trip and close devices shall be provided for manual operation of the breaker. Access to mechanical closing device shall be secured by suitable shrouding or shall be accessible only after opening the cubicle door. However, the mechanical trip device shall be brought out to the front of the cubicle door.

Auxiliary switches mounted on the fixed portion of the cubicles and directly operated from the breaker operating mechanism on each breaker having 2 'NO' and 2 'NC' potential-free contacts rated for 10 amps. 240V AC and 1.0 amp (inductive breaking) 110 V DC shall be provided. These contacts shall be in addition to those utilised in the control circuit of each breaker and shall be exclusively meant for the Purchaser's use in external interlocks and controls, indications/SCADA system.

c. Spring Operated Mechanism

Spring operated mechanism, shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply to the motor, at least one open-close-open operation of the circuit breaker shall be possible.

Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged, after closing a breaker, closing springs shall automatically be charged for the next operation. Motor shall be such that it requires less than 30 sec. for fully charging the closing spring. Motors shall be rated for 240V AC and shall operate satisfactorily at all values of voltage between 80 % and 110 % of rated voltage.

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Mechanical indicators to indicate 'charged' and 'discharged' condition of spring shall be provided. It shall be possible to charge the spring manually in the event of non-availability of the spring charging motor. Suitable spring charging handle shall be provided for this purpose. A mechanical operation counter shall be provided for the circuit breaker which shall indicate number of closing-opening operations the breaker has performed.

d. Operating Mechanism Control

The local electrical closing and tripping control shall be by a control switch mounted on the cubicle door. The mechanical trip and close devices shall be provided on the breakers in addition to above.

1.7 Safety Earthing Switches/ Earthing Trucks or cassettes

Suitable in-built earthing switches or earthing trucks/ cassettes shall be provided for safety during maintenance and for discharge of the cables.

The earthing devices shall have same short time rating as the main switchgear. Incoming line side earthing switches shall be provided with cautionary warning to prevent earthing of live incoming circuit. In case of earthing trucks/ cassettes, these shall provide pre-earthing audio-visual warning prior to earthing of live cable. Cable earthing switches shall be interlocked with the corresponding circuit breaker so that the earthing switch can be closed only when the circuit breaker is Off and vice versa.

1.8 Inspection and Testing

All Routine Tests according to IS or IEC shall be carried out on completely assembled switchgear assembly at the manufacturer's Works and the same shall be witnessed by Employer's Representative. The Employer's Representative shall also witness all the Routine and performance tests on the circuit breaker. In addition to these tests, the manufacturer of the equipment shall also carry out primary injection test for all current operated relays and meters.

Routine Test Certificates of all major items such as circuit breakers, CTs, VTs, protective relays and meters shall also be furnished to the client.

1.9 Typical Bill of Materials

a. Incoming to the Switchboard:

Sr. No.	Items	Qty.
1	630A, 11 kV, 500 MVA Vacuum/SF6 circuit breaker, horizontal draw-out, motorised spring charged, spring charging motor voltage 240V AC, closing and tripping coils rated for *V DC, complete with at least 4 NO (open) + 4 NC (closed) auxiliary contacts	1
2	Auxiliary relay/contactors for electrical anti-pumping, if not already built into the circuit breaker	1
3	Breaker control switch, Trip – Neutral – Close, spring return type	1

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Sr. No.	Items	Qty.
4	Indicating lamps R, G, A, W for CB 'On', 'Off', 'Tripped' & 'Trip Circuit Healthy' indications	4
5	CTs, */1-1A, 7.5 VA, Cl. 1.0 for metering & 7.5VA, Cl. 5P10 for protection	3
6	Electronic multi-function meter for metering	1
7	VTs, (11000/ $\sqrt{3}$)/(110/ $\sqrt{3}$)V/(110/ $\sqrt{3}$)V, 25VA, Cl. 1.0 & 25VA, Cl. 3P for metering complete with HRC fuses on HV side and MCB/fuses on LV side.	3
8	Trip Circuit Supervision relay for both 'On' and 'Off' positions of the circuit breaker	1
9	Triple pole IDMT Over-current relay for '51' function and single pole IDMT Earth-fault relay for '51N' function, numerical type.	1
10	High speed tripping relay, hand reset type, for lock-out function.	1
11	Facia annunciator, 4 windows type, complete with 'Accept', 'Reset' & 'Test' facilities	1
12	Set of MCBs/ fuses for isolation and protection of auxiliary supplies to the panel.	1

b. Buscoupler:

Sr. No.	Items	Qty.
1	*A, * kV, * MVA Vacuum/SF6 circuit breaker, horizontal draw-out, motorised spring charged, spring charging motor voltage 240V AC, closing and tripping coils rated for *V DC, complete with at least 4 NO + 4 NC auxiliary contacts	1
2	Auxiliary relay/contactors for electrical anti-pumping, if not already built into the circuit breaker	1
3	Breaker control switch, Trip – Neutral – Close, spring return type	1
4	Indicating lamps R, G, A, W for CB 'On', 'Off', 'Tripped' & 'Trip Circuit Healthy' indications	4
5	CTs, */1-1A, 7.5 VA, Cl. 1.0 for metering & 7.5VA, Cl. 5P10 for protection	3
6	Ammeter with selector switch	1
7	Trip Circuit Supervision relay for both 'On' and 'Off' positions of the circuit breaker	1
8	Triple pole IDMT Over-current relay for '51' function and single pole IDMT Earth- fault relay for '51N' function, numerical type	1
9	High speed tripping relay, hand reset type, for lock-out function.	1
10	Facia annunciator, 4 windows type, complete with 'Accept', 'Reset' & 'Test' facilities	1
11	Set of MCBs/ fuses for isolation and protection of auxiliary supplies	1

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	to the panel	
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c. Outgoing Transformer Feeder:

Sr. No.	Items	Qty.
1	630A, 11 kV, 500 MVA Vacuum/SF6 circuit breaker, horizontal draw-out, motorised spring charged, spring charging motor voltage 240V AC, closing and tripping coils rated for *V DC, complete with at least 4 NO (open) + 4 NC (closed) auxiliary contacts	1
2	Auxiliary relay/contactor for electrical anti-pumping, if not already built into the circuit breaker	1
3	Breaker control switch, Trip – Neutral – Close, spring return type	1
4	Indicating lamps R, G, A, W for CB 'On', 'Off', 'Tripped' & 'Trip Circuit Healthy' indications	4
5	CTs, */1-1A, 7.5 VA, Cl. 1.0 for metering & 7.5VA, Cl. 5P10 for protection	3
6	Electronic multi-function meter for metering	1
7	Trip Circuit Supervision relay for both 'On' and 'Off' positions of the circuit breaker	1
8	Triple pole IDMT Over-current relay for '51' function, Triple pole high set instantaneous over- current relay for '50' function and single pole instantaneous Earth-fault relay for '50N' function, numerical type.	1
9	High speed tripping relay, hand reset type, for lock-out function.	1
10	Auxiliary relays for contact multiplication of transformer 'fault trip' contacts	6
11	Facia annunciator, 12 windows type, complete with 'Accept', 'Reset' & 'Test' facilities	1
12	Set of MCBs/ fuses for isolation and protection of auxiliary supplies to the panel.	1

d. Outgoing Motor Feeder:

Sr. No.	Items	Qty.
1	*A, * kV, * MVA Vacuum/SF6 circuit breaker, horizontal draw-out, motorised spring charged, spring charging motor voltage 240V AC, closing and tripping coils rated for *V DC, complete with at least 4 NO + 4 NC auxiliary contacts	1
2	Auxiliary relay/contactor for electrical anti-pumping, if not already built into the circuit breaker	1
3	Breaker control switch, Trip – Neutral – Close, spring return type	1
4	Indicating lamps R, G, A, W for CB 'On', 'Off', 'Tripped' & 'Trip Circuit Healthy' indications	4
5	CTs, */1-1A, 7.5 VA, Cl. 1.0 for metering & 7.5VA, Cl. 5P10 for protection	3
6	Electronic multi-function meter for metering	1

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7	Temperature scanner, 8 channel type, suitable for Pt-100 sensors for motor winding and bearing temperature, where specified	1
8	Trip Circuit Supervision relay for both 'On' and 'Off' positions of the circuit breaker	1
9	Comprehensive Motor protection relay covering at least following functions: <ul style="list-style-type: none">• Thermal overload (49)• Stalled Rotor (50LR)• Instantaneous over-current (50)• Negative Phase Sequence over-current (46)• Earth over-current (50N)	1
10	High speed tripping relay, hand reset type, for lock-out function.	1
11	Facia annunciator, 6 windows type, complete with 'Accept', 'Reset' & 'Test' facilities	1
12	Set of MCBs/ fuses for isolation and protection of auxiliary supplies to the panel	1
13	DP MCB for motor space heater control	1

Note: (*) To be decided by the contractor.

2. TRANSFORMER – OIL COOLED TYPE

2.1 Scope

The scope of this specification covers the design, manufacture, supply, testing and delivery to site the Distribution transformers required.

The transformers up to 2500 kVA, 33 kV class shall conform to IS 1180-2014 revision. The transformers shall be Energy Efficient Level 3 with maximum losses at 50% load and at 100% load as defined in IS 1180.

2.2 Codes and Standards

The supply, installation, testing and commissioning of transformers and accessories shall comply with the latest applicable standards and codes of practices.

The list of some of the applicable Indian Standards is as given below:

IS 1180-2014	Outdoor Type Oil Immersed Distribution Transformers up to and including 2500 kVA, 33 kV - Specification
IS 335	New Insulating Oils
IS 2026	Power Transformers
IS 2099	Bushings for Alternating Voltages above 1000 V
IS 3639	Fittings and Accessories for Power Transformers
IS 6600	Guide for Loading of Oil Immersed Transformers

2.3 General

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Transformers shall comply with IS 1180-2014 & IS 2026. They shall be oil immersed, naturally cooled type classified ONAN.

The transformer shall be sized for continuous operation at its maximum rating under the climatic conditions defined in the Employer's Requirements. The rating shall allow for open, un-shaded operation.

2.4 Constructional Features

i. Tank

Tank shall be made from good commercial grade low carbon steel and shall be of welded construction. Tank shall be designed to permit lifting, by crane or jacks, of the complete transformer assembly filled with oil.

Tank shall be braced to withstand full vacuum and pressure test as specified by CBIP's (Central Board of Irrigation & Power) latest specification. Suitable guides shall be provided in the tank for positioning the core and coil assembly. The core and coil assembly shall not be cover mounted.

Adequate space shall be provided at the bottom of the tank for collection of sediment. The transformer base shall be designed to permit skidding of the complete transformer unit in any direction, when using plates or rails. The under-base shall be detachable unless transport facilities permit a fixed base.

The transformer top shall be provided with a detachable cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water. The material used for gaskets shall be rubberised cork.

ii. Core

The magnetic circuit shall be of "core type" construction. The core shall be built out of high grade, non-ageing, low loss and high permeability, cold rolled grain oriented silicon steel laminations adequately insulated and joints mitred and interleaved to provide continuity of the magnetic circuit.

After being sheared the laminations shall be treated to remove all burrs. Both sides of the laminations and the cut edges shall be treated with appropriate insulation. The finally assembled core shall be free from distortion. It shall be rigidly clamped to ensure adequate mechanical strength and to prevent vibrations during operation.

The core clamping structure shall be designed to minimise eddy current loss. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coils assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits.

All steel sections used for supporting the core shall be thoroughly sand-blasted, after cutting drilling and welding. The operating flux density 'B' shall be so chosen that the core does not get into saturation at 110% of the rated voltage. The operating flux density shall be of the order of 1.65 to 1.7 Tesla. Cross-sectional area for this purpose shall be adequate.

iii. Windings

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Windings shall be of copper. Windings shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

Coils shall be supported at frequent intervals by means of wedge type insulation spacers permanently secured in place and arranged to ensure proper oil circulation. To ensure permanent tightness of winding assembly, the insulation spacers shall be dried and compressed at high pressure before use.

Windings shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness. Materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or be otherwise affected under the operating conditions.

All threaded connections shall be locked. Leads from the winding to the terminal board and bushings shall be rigidly supported to prevent it from vibration. Guide tubes shall be used where practicable. Windings and connections shall be braced to withstand shocks during transport or short circuits.

Coil clamping rings shall be of steel or of a suitable insulating material built from flat laminations. Permanent current carrying joints in the windings and lead shall be brazed or soldered. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Terminals of all windings including unloaded stabilising windings shall be brought out of the tank through bushings for external connection.

iv. Bushings

- a) All bushings shall conform to the requirements of latest revision of IS: 2099. The bushing ratings shall be commensurate with the transformer rating and shall not pose any limitations on transformer overload capacity. Impulse withstand levels shall be in accordance with the Standards mentioned and creepage distance shall be suitable for severely polluted atmosphere (minimum 31 mm/ kV).
- b) All porcelain shall be sound, free from defects and thoroughly vitrified. The glaze shall not depend upon insulation, shall be smooth, hard, of uniform shade of brown and shall cover completely all exposed parts of insulator. Porcelain shall not engage directly with the hard metal and, where necessary, approved gasket shall be interposed between porcelain and fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.
- c) Connection from the main winding to the bushing shall be flexible.
- d) Clamps and fittings made of steel and malleable iron shall be galvanised.
- e) Bolt threads shall be greased before erection
- f) Each porcelain bushing shall have the manufacturer's identification marks.
- g) Bushing insulators are to be mounted on the tank in a manner such that the external connection can be taken away clear of all obstacles. Neutral bushing shall be mounted in a position from which a connection may be taken.
- h) The bushing shall be so located as to provide minimum electrical clearances between phase and also between phase and ground as per the IS 2099.

v. Oil

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Transformer and associated oil filled equipment shall be supplied with first filling of oil plus 10% extra in non-returnable drums. The oil shall conform to IS: 335. No inhibitors shall be used in the oil. In all cases, oil will not contain any polychlorinated biphenyl (PCB).

vi. Cable Terminations

Cable termination boxes for ground-mounted transformers shall be suitable for dry termination of HV cables and LV cables / bus duct. Non-magnetic gland plates shall be provided for the termination of single core cables.

LV neutral shall be brought out through 1.1 kV rated bushing for forming 3 ph., 4 wire system. An extra LV Neutral bushing shall be provided and shall be directly connected to earth by means of two nos. earthing conductors. Bushings rated above 1000 VAC shall comply with IS 2099. It shall be possible to remove the cable boxes without dismantling the cable glanding or draining the oil.

vii. Cable Box with Disconnecting Chambers

Air insulated cable box shall be provided on provided on H.V. side. The disconnecting chamber shall be air insulated. Phase to phase and phase to ground clearances with the cable box shall be as per CBIP.

viii. Bus Duct Termination

Distribution transformers with secondary voltage as 433 V and rated above 1000 kVA shall be provided with a flanged throat or equivalent connection for termination of bus ducts. The bus duct throat arrangement shall be suitable for vertical and horizontal take off. The bus duct throat shall be on the side wall of a tank. Transformers rated below 1000 kVA shall be provided with cable termination box.

ix. Transformer Cooling Equipment

Transformers of rating below 500 kVA shall be equipped with fixed type radiators and transformers of rating 500 kVA and above shall be provided with detachable or separately mounted radiator banks. Tank mounted radiators shall be of the detachable type with bolted flanged connections. Sheet steel thickness for the radiators shall not be less than 1.2 mm. The following accessories shall be provided for each radiator:

Shut off valves and blanking plates on transformer tank at each point of connection, Top and bottom shut off valves and blanking plates on each radiator, Lifting lugs, Top oil filling hole with cap, Air release plug at top, Oil drain plug at bottom.

2.5 Fittings and Accessories (R – Required, NR – Not Required)

Sr. No.	Description	Rating of Transformer to which fitted			
		Up to 400 KVA	500 to 800 KVA	1000 to 2000 KVA	2500 KVA & above
1	Rating & diagram plate	R	R	R	R
2	Dial type magnetic oil level gauge with low level alarm contacts	NR	NR	R	R

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3	Silica Gel breather with a seal & connecting pipe, in a transparent enclosure	R	R	R	R
4	Explosion Vent with diaphragm, Equalising pipe	R	R	R	R
5	Conservator with filling hole, cap and drain valve and isolating valve for conservator.	R	R	R	R
6	Double float buchholz relay with alarm and trip contacts and a test lever for simulating operation of buchholz relay and shut off valve on both sides.	NR	R	R	R
7	Dial thermometer for oil temperature marked in o C with alarm and trip contacts (adjustable) with a maximum reading pointer	R	R	R	R
8	Image coil with C.T. test terminals, calibrating resistors etc. for winding temperature with dial type thermometer having alarm & trip contacts (adjustable) with a maximum reading pointer	NR	NR	R	R
9	Weather-proof marshalling box with terminal blocks complete with PVC armoured cables terminated with glands, for alarm/trip contacts of buchholz relay, OTI & WTI etc.	R	R	R	R
10	Thermometer pocket (for top oil temp.)	R	R	R	R
11	Lifting lugs	R	R	R	R
12	Jacking pads – 4 Nos.	NR	NR	R	R
13	Draw eyes	NR	NR	R	R
14	Top Filter valve	R	R	R	R
15	Bottom filter valve	R	R	R	R
16	Drain valve with plug	R	R	R	R
17	Oil sampling valve	R	R	R	R
18	Inspection cover	R	R	R	R
19	Air release vent	R	R	R	R
20	Bi-directional rollers	R	R	R	R
21	Two earthing terminals	R	R	R	R
22	Plain oil level indicator with minimum marking	R	R	R	R

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23	Extra LV Neutral bushing for direct earthing, in addition to one for power system	R	R	R	R
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2.6 Noise Level

The noise level when energised at normal voltage and frequency shall not exceed 78 dB when measured one meter from edge of transformer.

2.7 Painting

The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and dust and surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. Steel surfaces exposed to the weather shall be thoroughly cleaned and applied a priming coat of zinc chromate. The second coat shall be of an oil and weather resistant nature, preferably of different colour from the prime and finish coats. The final coat shall be of glossy oil and weather resisting non fading epoxy paint of specified shade. All exposed bolts, nuts and washers shall be of stainless steel.

Metal parts not accessible for painting shall be made of corrosion-resistant material. Machine finished and bright surfaces shall be coated with a suitable compound and wrapped. Interior surfaces of mechanism chambers and knocks shall receive three coats of paint after proper cleaning. The final coat shall be of a light coloured anti-condensation paint.

2.8 Operational Requirements

Voltage and Frequency Variations

Transformers shall operate without injurious heating, on any tap, under the following conditions, provided increase in voltage is not accompanied by reduction in frequency: At rated kVA, with voltage variation of (+) or (-) 10% of the voltage corresponding to a particular tap.

At rated current, with 105% rated voltage.

Transformer shall accept, without injurious heating, combined voltage and frequency fluctuations which produce 110% over fluxing conditions.

Operating Under Overloads

It shall be possible to operate the transformer as per loading guide IS: 6600 up to overloads of 150%. There shall be no limitations imposed by bushings, tap changers, auxiliary equipment, etc. to meet this requirement.

2.9 Tests

The following tests shall be conducted in presence of the Employer's Representative; All routine tests, Heat run test (on mutually agreeable basis) Oil Pressure Test Vendor shall submit the S.C. test withstand certificate for similar transformer.

2.10 Losses

The total maximum losses at 50% load and 100% load shall be within the limits specified in IS 1180 – 2014.

2.11 Specification of O.L.T.C & A.V.R

a. On Load Tap Changer

On load Tap changer suitable for application at all locations of 11 kV, 3 phase, Star or Delta connected transformers. It is a linear gear, requiring a potentiometric tapping arrangement with a Wander lead. The Tap Changer has a max. of 9 positions so that it can be applied to a winding of 8 steps, to give 9 different voltages. The functions of the tap selector and diverter Switch are combined in a selector switch. The Selector Switch and its integrally mounted stored energy type Driving Mechanism, are housed in a sheet steel tank, with a Flange suitable for mounting on a port on the Transformer tank. Leads can be brought out of the transformer through a Port Flange mounted, oil tight, Terminal Barrier Board, which is part of the Tap changer supply. The Tap changer must be connected to a conservator, through an Oil Surge Protective Relay. The Oil Surge Protective Relay forms part of Tap changer Supply. The Transformer Manufacturer must fill the Tap changer with oil. The Tap changer must conform to Type tests and Routine tests as per IS: 8468.

b. Technical Data:

Rated Voltage	:	11KV
Maximum System Voltage	:	12 KV
No. of positions	:	9
No. of Phases	:	3
Maximum Continuous current	:	200 A
Maximum Operating step voltage	:	300 V
Maximum Operating voltage over Tapping range	:	6000V
Maximum Continuous voltage to ground	:	12,000V
Maximum Continuous voltage Between phases	:	12,000V
Peak emergency current	:	450 A
Time per tap change	:	4-6 Sec.
Weight of Tap changer without oil	:	370 Kgs.
Weight of Tap changer with oil	:	610 Kgs.
Oil content	:	230 Lts.
Transition switching time	:	50 milli.secs.

c. Automatic Voltage Regulating Relay

Automatic Voltage Regulating Relay designed for maximum Operational simplicity for regulating the secondary voltage of power transformers with On Load Tap Changer. The dead band (band width) can be set by setting the nominal value adjustment (NVA) to the required value (110V+10%) & then setting the L & R Limits around the NVA within 0.5v to 5v.

The desired time delay can be set up on the front panel and the control action will take place only if the voltage continues to remain outside the dead band after the time delay has elapsed. For voltage corrections requiring more than one tap change, time delay is initiated again before further tap change. The relay is reset automatically after the voltage is brought within the selected dead band, the time

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delays is effectively reduced to provide a voltage time integral response of the regulator.

Operation of the Raise Control Relay is automatically inhibited when the voltage falls below the specified under voltage limit or it falls. One pair of normally open relay contacts is provided to affect the tap changer during Raise and Lower operation and to trigger an alarm in case of under voltage/ P.T fail conditions.

d. Specifications

Auxiliary supply	:	110 V/ 230V AC \pm 15% 50Hz, 15 VA
PT Supply (Regulating Voltage)	:	110V \pm 10%, 50Hz., 1.5VA
Sensitivity (Dead Band) And Nominal value Range	:	1) Nominal value adjustable (NVA) between \pm 10% of 110V and readable on DPM. : 2) L setting adjustable between 0.5v to 5v above the NVA and readable on DPM. : 3) R` Setting adjustable between 0.5v to 5v below the NVA and readable on DPM. : 4) Actual PT voltage also readable on DPM.
Time delay setting	:	Fixed (voltage independent) time delay continuously adjustable from 10 to 120 seconds.
Time delay Resetting	:	Instantaneous resetting with voltage deviation occurring in opposite direction.
Under voltage blocking	:	Internal blocking at 80% of NVA Restoration at 85% of NVA (other values available on request)
Controls Relays	:	One pair of normally open potential free contacts of rating 5A at 220V AC of 24V DC resistive load for each lower, raise and under voltage control relays.
Control Operation	:	Single Pulse operation with 5 seconds (approx.) on time.
Operating Temperature	:	0 – 50°C.
Size	:	Panel cutout dimensions 330 x 135mm Depth 260mm approx. Mounting Hole Dimensions 360mm \pm 2mm x 100mm \pm 2mm (¼" \varnothing x 4)

3. 11 KV XLPE CABLE

3.1 Scope of Work

The specification covers design, engineering, manufacture, stage testing, inspection and testing before supply, delivery at site, installation, testing & commissioning of 11 KV, XLPE cables for use with effectively earthed distribution system.

3.2 Standard to be Followed

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The materials shall conform in all respects to the relevant Indian Standards Specification with latest amendments thereto.

Indian Standard No.	Description
IS-7098 Part-II/1985	Cross Linked Polyethylene Insulated PVC Sheathed Cables for working Voltages from 3.3 KV up to and including 33 KV
IS-5831/1984	PVC insulation and sheath of Electric cables
IS-8130/1984	Conductors for insulated electric Cables and Flexible cords
IS-10418/1982	Drums for electric cables

3.3 Technical Requirement

(a) Main Features

The Power Cable shall be 11 KV Grade, high conductivity, stranded compacted circular Aluminium Conductor, XLPE insulated, extruded inner PVC sheathed, galvanized steel strip armoured with overall separate extruded PVC outer sheathed, conforming to relevant standards suitable for 11 KV three phase 50 cycle second earthed system.

3.4 Materials and Construction

(a) Conductor

The cable conductor shall be made from stranded aluminium to form compacted circular conductor having resistance within the specified limits as per relevant standards.

(b) Conductor Shield

The conductor shall have a non-magnetic semi-conducting screen, which will ensure perfectly smooth profile and avoid concentration. The Conductor screen shall be extruded in the same operation, as the insulation.

(c) Insulation

The XLPE insulation shall be suitable for specified system voltage. The manufacturing process shall ensure that insulation is free from voids. The insulation shall withstand mechanical thermal stresses under steady state and transient operating condition. The extrusion method shall give smooth interface between semi-conducting screen and insulation.

(d) Insulation Shield

To confine electrical field to the insulation, insulation screening consisting of two parts, namely metallic (non-magnetic) and non-metallic (semi-conducting) shall be provided over the insulation of each core. The non-metallic insulation shield shall be extruded in the same operation as the conductor shield and the insulation by the triple extrusion process. The insulation shield shall be of bonded type and strippable on adequate heating. Metallic screening of copper tape shall be provided over non-metallic shield as per relevant ISS.

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(e) Inner Sheath

An extruded PVC inner sheath shall be provided over laid up cores. The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of thickness as per the relevant standards, consistent quality and free from all defects. The binding tape used over the laid up cores shall not be constructed as a part of the inner sheath.

(f) Armour

Armouring shall be applied over inner sheath with galvanized steel strip complying with the requirements of relevant standards. The armour strips shall be applied as closely as possible. The joints in armour strip shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any strip shall be at least 300 mm from the nearest joint in any other armour strip in the completed cable.

(g) Outer Sheath

Extrude PVC outer sheath shall be applied over armouring with suitable additives to prevent attack by rodents and termites. Outer sheathing shall be designed to offer high degree of mechanical protection and shall also be heat, oils, chemicals, abrasion and weather relevant. Common acids, alkalies, saline solutions etc., shall not have adverse effects on the PVC sheathing material used.

(h) Construction

The cable shall have suitable PVC fillers laid up with insulation cores to provide substantially circular cross section before the inner sheath is applied. The fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials used in the manufacture of cable shall be new, unused and of finest quality. All materials shall comply with the applicable provisions of the tests of the relevant standards. The PVC material used in the manufacture of cable shall be of reputed make. No recycling of the PVC is permissible. The purchaser reserves the right to ask for documentary proof of the purchase of various materials to be used for the manufacture of cable and to check that the conductor is complying with quality control. The cable shall be suitable for laying in covered trenches and/or buried underground to meet the outdoor application purposes.

(i) Current Rating

The cables shall have current ratings and derating factors as per relevant Indian Standards. The current ratings shall be based on maximum conductor temperature of 90 deg. C with ambient site condition specified for continuous operation at the rated current. The one-second short circuit current rating shall be as per table given below at maximum temperature of 250 °C.

(j) Operation

Cables shall be capable of satisfactory operation, under a power supply system frequency variation of +/- 5 c/s. voltage variation of +10% to -15%. Cable shall be suitable for laying in

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ducts or underground. Cables shall have heat and moisture resistance properties. These shall be of type and design with proven record on Distribution Network service.

(k) Identification

For identification of individual cores, coloured strips of red, yellow and blue colours respectively shall be used on the cores to identify phase conductors as per relevant ISS.

(l) Embossing

The cable shall be embossed throughout the length with the name of the manufacturer or trade mark. Voltage grade with cable size and the year of manufacture. The embossing shall be done only on the outer sheath, the distance between any two consecutive embossing shall not be more than 1 Meter. The cable shall be embossed for the verification of its length at intervals of 1 Meter say 1, 2, 3, up to full length.

(m) Test

Type Test: The material offered shall be fully type tested at recognized test laboratories by the Bidder as per the relevant standards but test reports shall not be more than five year old from the date of opening of bid.

Acceptance and routine test: All acceptance and routine tests as stipulated in the relevant standards shall be carried out by the supplier.

4. LT XLPE CABLE

4.1 Scope

The specifications cover requirement of 650 / 1100 Volts grade solid/stranded, Copper/Aluminum conductors, XLPE insulated and sheathed galvanised round/flat steel wire armoured and PVC overall sheathed cables.

4.2 Code and Standards

The cables shall comply with all currently applicable IS / IEC Standards, Electricity Rules, approval of Fire Insurance Association and Electrical Inspector.

Unless otherwise specified, cable shall conform to the following latest applicable Standards.

IS	1554,Part -I	1988	PVC insulated (heavy duty) electric cables for working voltages up to and including 1100 V
IS	7098,Part-I	1988	Cross linked polyethylene insulated PVC sheathed cables for working voltage up to and including 1100 V
IS	8130	1984	Conductors for insulated electric cables and flexible cords
IS	5831	1984	PVC insulation and sheath of electric cables

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IS	3975	1999	Mild steel wires, formed wires and tapes for armouring of cables
IS	10810,Part 41	1984	Methods of test for cables : Mass of zinc coating on steel armour
IS	209	1992	Zinc Ingot
IS	3961 Part-2	1967	Recommended current ratings for cables: Part – 2 PVC insulated and PVC sheathed heavy duty cables
IS	10418	1982	Drums for electric cables
IS	10810 Part 58	1998	Method of test for cables : Part 58 Oxygen Index test
IS	10810 Part 61	1988	Method of test for cables : Part 61 Flame Retardant test
IS	10810 Part 62	1993	Method of test for cables : Part 62 Fire resistance test for bunched cables
IS	694	2010	PVC insulated unsheathed and sheathed cables for rated voltage up to and including 450/750 V

The cables and accessories shall also conform to the provisions of Indian Electricity Rules and relevant statutory regulations.

4.3 Climatic Conditions

Cables shall be installed in air / ground, in atmosphere having maximum ambient temperature and relative humidity as per prevailing site condition.

4.4 Constructional Requirement

(a) Conductor

The material of conductor shall be Electrical grade high conductivity, compacted, aluminium / copper. Conductor shall be solid for conductor of nominal area up to and including 4 sq.mm and stranded beyond 4 sq.mm. Conductors of nominal area less than 25sq.mm shall be circular or sector shaped. Cables with reduced neutral conductor shall have sizes as per table 1 of IS 1554 (part-1). Cables up to and including 4 sq. mm shall be of Cu and above 6 sq. mm shall be of Al unless specified otherwise. Strand details shall be preferably as below:

6 to 10 sq mm [CU/AL]	-	7 strands
16 to 50 sq mm [CU/AL]	-	7 strands
70 to 150 sq mm [CU/AL]	-	19 strands

(b) Insulation

The material of insulation shall be Cross Linked Polyethylene applied over the conductor by extrusion. Insulation shall be free from contamination and water voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. The thickness of the insulation shall be as per IS: 7098 (part I).

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(c) **Inner Sheath**

The inner sheath shall be applied over the cores by a method of extrusion and shall be of PVC conforming to the requirements of Type ST-1 PVC compound as IS: 5831. The thickness of inner sheath shall be as per relevant standards. There will be no sheath for single core cables, in case of single core when there are both metallic screening and armouring there shall be extruded inner sheath between them.

(d) **Armouring**

If armouring is specified for multicore cables, the same shall be single round galvanised steel wires / galvanised steel strips as per the requirement. If armouring is specified for single core cables, the same shall be with H4 grade hard drawn aluminium round wire of 2.5 sq.mm diameter.

Requirement and methods of tests for armour material, galvanising uniformity and dimensions of armour shall be as per relevant standards.

(e) **Outer Sheath**

This shall consist of extruded ST-1, PVC compound having oxygen index value of minimum 28 % at 27 ± 2 deg. C, is resistant to termite and rodent attack. Outer sheath shall be of black colour, external surface of which shall be embossed with voltage designation and manufacturer's name at regular interval. The thickness of outer sheath shall be as per IS: 1554 – part 1.

Sequential marking of the length of the cable in metre shall be provided on the outer sheath at every one metre. The embossing / engraving shall be legible and indelible.

PVC / Rubber end caps shall be supplied free of cost for each drum with a minimum of twenty per thousand metre length.

Outer sheath with FRLS compound shall be provided for better fire resistance.

(f) **General Requirements**

The cables shall be suitable for laying in trays, trenches, ducts, conduits and for underground buried installation with uncontrolled backfill and possibility of flooding by water and chemicals. Cables shall be suitable for keeping in a proper looped position for longer period without occurring of any damage to the insulations and armour.

The material of conductors shall be from annealed high conductivity Copper / Aluminum. The maximum conductor temperature in deg.0C shall be limited to data as specified in data sheets. Conductor shall be of either circular or sector shaped stranded conductor or circular solid construction as specified in data sheet.

Cables shall be supplied wound on non-returnable wooden drums of heavy duty construction and of suitable barrel diameter and shall be covered fully with wooden battens. Wooden drums shall be properly seasoned and treated with anti-rodent material and painted with good quality paint to increase the life of the drum. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit or storage.

Drums shall be suitably marked with manufacturer's name, customer's name, project title, cable type, size, voltage grade of cable, length of cable in metres, drum number, IS certification mark, gross weight, rolling direction etc. as per BIS/BS.

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Packing should be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC / heat shrinkable end caps so as to eliminate the ingress of water during transportation, storage and erection.

The cable of one size shall be in one length only, if the requirement is less than full standard drum length. Cables shall be suitable for earthed system. Negative tolerance on cable drum length is not acceptable.

(g) **Test**

Type Test: The material offered shall be fully type tested at recognized test laboratories by the Bidder as per the relevant standards but test reports shall not be more than five year old from the date of opening of bid.

Acceptance and routine test: All acceptance and routine tests as stipulated in the relevant standards shall be carried out by the supplier.

5. CABLING SYSTEM

5.1 General

The cabling system covers laying of all types of cables in tray, trench, direct buried in ground, pipe, duct, conduit etc. as required at site. Scope also includes supply of cable trays, racks, duct, supports and associated accessories, hardware and their installation. It shall be the responsibility of the contractor to complete the cabling system in all respects.

The following points shall be considered while planning cabling system:

- (i) Inside the building: Cable shall be laid on overhead trays fixed to wall or hanged to the ceiling. Cable may also be laid on trays inside cable trench covered with MS chequered plate but in this case, the bottom of cable trench shall be at least 100 mm above flood level in that area to avoid any water seepage/logging problem in future.
- (ii) Outside the building/outdoor plant area: Cable shall be laid on overhead tray mounted on suitable support. Removable cover allowing adequate ventilation shall be provided on overhead cable tray. Direct buried cable can be adopted in case of laying of HT power cable. At road crossing overhead trays shall be installed at 5000 mm (minimum) above ground level.
In addition, cables may also be laid in proper trenches/RCC Hume pipes/DWC pipe etc. as per site condition and as approved by employer's Engineer.
- (iii) Required clearances as per IS 1255 shall be maintained between power, control, instrument, PLC/data cables.
- (iv) Entry/exit of cables to building shall be through sloped pipe sleeves only which shall be sealed after installation of cables to avoid seepage of water inside building.
- (v) Cable shall be arranged in the trays/trenches in such a manner that criss-crossing of cable is avoided.
- (vi) Cable routing between cable trench and equipment/motors shall be taken through GI pipe sleeves of adequate size.

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- (vii) Cable routing shall be coordinated to avoid interference with structure, drains, piping etc.
- (viii) Cable marker shall be placed at every change in direction of cable routing and every 30 metre interval.
- (ix) Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.
- (x) All cables shall be identified close to their termination point by cable tag numbers as per cable schedule.
- (xi) Cables shall be clamped to the cable tray at regular intervals.
- (xii) All cable trays (Ladder/Perforated type) shall be minimum 2mm thick and hot dip galvanized (with Zinc coating of 610 gm. /sqm or 85 micron thickness) while supports shall be painted.
- (xiii) All support shall be structurally designed to take weight of cable, tray & support and wind force.
- (xiv) All steel sections such as angles, channels, and brackets etc., required for supporting the cable trays shall be provided by the contractor.

5.2 Installation of Cables

The Contractor shall install, test and commission the cables in accordance with above guidelines, approved drawings and IS-1255. The Contractor shall also supply the necessary materials and equipment required for jointing and termination of the cables.

Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor. The Contractor shall seal the cables into the bushes using fire resisting materials to prevent the spreading of fire through each partition. Sharp bends and kinks in cables shall be avoided. The bending radii for various types of cables shall not be less than 15 times the overall diameter of the cable. Power, control and instrumentation cables shall be laid in separate cable trays.

Where cables cross roads or water/sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings, the pipe for the cables shall be buried at not less than one metre depth. Care shall be taken to avoid sharp bending or kinking cables, damaging insulation or stressing cable beyond manufacture's recommendations in pulling. Cable shall be protected at all times from mechanical injury and from absorption of moisture at unprotected ends.

Control cable termination shall be made in accordance with wiring diagrams, using proper colour codes for the various control circuit, by code marked wiring diagram.

Metal sheath and armour of the cable shall be bonded to the earthing system. The size of conductor for bonding shall be appropriate with the system fault current.

All cables shall be tested for insulation resistance before jointing. After jointing is completed, all cables shall be tested again by a 1000 volt megger. Cable core shall be tested for;

- (i) Continuity;
- (ii) Absence of cross phasing;
- (iii) Insulation resistance to earth; and
- (iv) Insulation resistance between conductors.

Contractor shall provide testing kits and instruments required for field testing.

6. L.T. BUS DUCT

6.1 Scope

This section covers design, manufacture, inspection, transportation to site, installation, testing and commissioning of Low voltage bus duct for connection between Transformer secondary and LT panel.

6.2 General

The layout of the bus ducts shall be prepared in line with the site conditions and shall be got approved by Engineer-in-charge. All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.

6.3 Standards

The bus duct works shall conform to up-to date amendments and relevant standards/code as applicable.

6.4 Design

Bus duct shall be Non-segregated phase suitable for 415 volts, 3 Phase & Neutral, 50 Hz, AC supply both indoor and outdoor installation as per site requirement. Bus duct shall be designed to withstand the fault level of 50KA for 1 second. Bus duct shall be designed for continuous current rating as given in the BOQ.

6.5 Construction

a. Enclosure

All the three phases shall be enclosed in a weather proof, dust tight enclosure, Outdoor section of the bus duct shall be completely rain proof. Weather resistant type circumferential gaskets shall be provided for making the joints with adjacent enclosures dust – proof and impervious to moisture suitable inspection opening with gaskets shall be provided for access to support insulator, lugs joints etc. Bus duct enclosure shall be made of 14 swg. (2mm) CRCA sheet steel, for bus rating below 3000A. The degree of enclosure protection shall be IP 52 for indoor application and IPW-55 with canopy for outdoor section of the bus duct. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and vermin. Suitable means shall be provided to isolate the transformer vibration from rest of the bus duct. For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be limited to the site permissible values stipulated in relevant standards and/or this specification. Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the short-circuit currents without any damage or deterioration of material. The L.T. bus ducts shall be self-cooled and shall not be equipped with blower or any other type of forced ventilation.

6.6 Detailed Specifications

a. Bus-Bars

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(a) Material

Bus bars shall be made up of high conductivity electrolytic quality aluminum as specified in BOQ with maximum temperature limited to 85 deg. C (i.e. 35 deg. C rise over 50 deg. C ambient).

(b) Current density

The Aluminum bus bars shall be of sufficient cross section. The design current density of 1Amp/Sq. mm for aluminum bus bars shall be maintained. However, the design shall be suitable for the 50 KA fault level.

(c) Neutral bar rating

The rating of the neutral bar shall be minimum 50% of the phase bar.

(d) Joints

Adequate contact pressure shall be ensured by means of two bolt connection with plain & spring washers and locknuts. All bus joints shall be silver plated. Bimetallic connectors shall be provided for connections between dissimilar metals. The bus conductor shall be designed for bolted connections throughout the run. Joints for the bus bar shall be bolted but joints of construction with double cover fish plates and with adequate contact area.

(e) Insulation & supports

Bus bars and connections shall be fully insulated for working voltage with heat shrink colour coded PVC insulating sleeves. Bus insulators shall be flame-retardant, non-hygroscopic, track resistant type with high creepage surface materials like fiber glass reinforced thermosetting plastic/ epoxy/ FRP. The supports shall be made of single piece. They shall withstand without any damage or deformation the thermal and dynamic stresses due to short circuit currents.

(f) Color coding

Bus bars shall be colour coded for easy identification (Red, Yellow, Blue for three phases and Black colour for neutral for A.C 3 phase system). Heat shrinkable, colour coded PVC insulation sleeve shall be used for this purpose.

(g) Lay out sequence

Sequence shall match both transformer and LT Panel end.

(h) Clearances & creepage distances

As far as possible, large phase and ground clearances and creepage distances shall be provided on the bus bar system to minimize possibilities of fault. The clearance mentioned below shall be minimum and maintained even at the connection point. 1 Phase to Phase – 35 mm 2 Phase to Neutral – 28 mm 3 Phase to Earth – 28 mm.

b. Hard Ware

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Zinc passivated or any other superior quality standard size hard ware to be used for all joints/ connections/ terminations at switchgear & control gear, bus bars, ground bus, interconnections/ wiring etc.

c. Convenience of maintenance

The system shall be maintenance friendly. i.e. it should be possible to easily connect/tighten/disconnect etc.

d. Inspection Covers

Inspection covers shall be provided at suitable intervals as required.

e. Disconnect Link

Removable bolted disconnect link shall be provided in the bus for the purpose of isolation. Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties. The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus. A minimum clearance of 300 mm (12") shall be provided between the disconnected bus sections with the link removed.

f. Ventilation

The bus duct shall be natural cooled.

g. Joints, Expansion/Flexible joints

The bus bar shall be supported in such a way that the expansion/contraction does not have undue strain on the bus and at the terminals at both ends. Circumferential neoprene gaskets shall be provided for dust tight joints with adjacent enclosure section. The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. 28 Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion/contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures. Flexible connections shall be provided between bus sections to allow for expansion and contraction of the conductor. Flexible connection shall also be provided at all equipment terminations. All contact surfaces shall be silver plated to ensure an efficient and trouble free connection.

h. Other points

Shipping length of the bus duct shall be not more than three (3) meters in length. Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.

i. Ground Bus

Two numbers of Earth bars shall run along the full length of bus duct made up of size 50 mm X 5 mm Aluminium, strip. This ground bus shall be fixed to the bus duct on the external side. It shall have provision to connect main earth/loop earth conductors with bolts, nuts, washers & spring washers. Metallic parts of the bus duct & associated structures etc. shall be bonded to the ground bus for effective earthing. One end of the

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earth bus shall be joined to the LT Panel side body earth lead and the other end shall be joined to the transformer body earth.

j. Installation

All supporting structures required for hanging and/or supporting the complete bus duct shall be provided including related civil works. These include all types of supports, brackets, beams, channels, rods, clamps, hardware, etc. to support with wall, roof, truss etc. Bus ducts running along the wall should be supported at intervals not exceeding 1.5m. In case of branching, there should be a support on all branches at a distance of 30 cms from the point of branching. Support should not be less than 40mm X 40mm X6mm MS angle secured in an approved manner. Supports may also be formed as brackets fixed to walls where runs are along with walls. Supports shall be grouted on the walls. In case of ceiling suspended bus ducts, supports made of 40mm X 40mm X6mm MS angle iron shall be provided. The horizontal interval between two such supports should not be more than 1200mm. However, additional supports to be given at the bends and termination points. These duct supports shall be suspended from the C.I./MS. boxes or suitable approved suspension device provided in the ceiling by means of 12 mm diameter MS rods. Where fish plates are available, the same can be used for bus duct support works. Where there is no such provision, good quality anchor fasteners of size not less than 8mm shall be used in the ceiling. 29 Seal-off bushings complete with wall frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between two portions of the bus duct part of which is indoor while the other is outdoor. Silica-gel breather shall be provided on both portions of the bus duct between the seal of bushings.

k. Connections & Terminations

All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the bus duct at the switchgears, transformers and other equipment shall be provided. Flexible connections both for conductor and enclosure shall be provided. a) At all equipment termination to provide for misalignment up to 25 mm (1") in all directions. b) Between bus duct supported from building steel to prevent transmission of vibration. The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing. If the material of bus conductor and that of the equipment terminal connectors are different then suitable bi-metallic connectors shall be furnished.

l. Painting

Unless otherwise specified, the painting process shall be as follows:-

All steel surfaces shall be thoroughly cleaned by sand blasting or chemical agents, as required, to produce a smooth surface free of scales, grease and rust etc. The steel surfaces after cleaning shall be given on all sides proper coat of anti-corrosive primer followed by two coats of powder coating painting. The bus duct shall be finished with two coats of grey (IS 5 shade # 632) powder coated paint. Earth strip shall be painted with green colour enamel paint. Where the painting is damaged during transit, installation etc., and touch up painting shall be done at site. All metallic parts involved in the installation like supports, beams, channels, brackets, clamps, poles, hardware etc. shall be enamel painted.

m. Tests

(a) Factory Test

The routine/acceptance tests as per relevant IS may be witnessed at the manufacturer's works by client/ representative.

(b) Type Tests

Bus duct shall be got manufactured by only reputed bus duct manufacturers having type tested as per IS by CPRI or other government testing laboratory on similar bus duct (s) with minimum 50KA short circuit current with stand capacity and the type test certificate shall be produced to the client/representative at the time of factory test.

(c) Site Tests

In addition to the tests at manufacturer's premises, all relevant pre-commissioning checks and tests shall be done at site before energizing the bus duct. The following tests are to be particularly done before connecting the bus duct.

- i) Physical inspection for breakages/damages/orderliness.
- ii) Insulation resistance test with 500 V Megger. The insulation resistance shall not be less than 100 mega ohms.
- iii) Earth continuity test. All test results are to be recorded and reports should be submitted to the department.

7. LT PANEL

7.1 General

The offered Panel shall be brand new with state of the art technology and proven field track record. Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.

The panel shall be free standing floor mounted with complete front access for operation and maintenance. The panel shall be fixed type (draw out type for ACB feeder) in single front execution, assembled in single line up, metal enclosed, fully compartmentalised, totally segregated compartments for feeders, cables and bus bar, dust and vermin proof suitable for indoor installation.

All hardware shall be corrosion resistant. All joints and connections of the panel members shall be made of galvanised or zinc passivated cadmium plated high quality steel bolts, nuts and washers secured against loosening. All openings, covers and doors shall be provided with gaskets around the perimeter to make the switchboard dust and vermin proof. Suitable lifting hooks shall be provided for each shipping section for ease of lifting of panel.

The panel shall comprise of incoming ACB and Bus-coupler ACB with required protection, digital multi-function meter, surge protection device, indication lamps. Outgoing shall consist of VFD, Soft Starters/ Automatic Star-delta Starters, DOL

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Starters, MCCBs, digital multi-function meter, L/R selector switch, start-stop push button, indication lamps etc. complete with required protections. Panel shall also comprise control supply transformer, both power and auxiliary/control bus bars, cable termination compartments etc. The incomer of the panel shall be electrically & mechanically interlocked so that only one incomer (main or DG supply) is On at a time.

All feeders shall be of modular design with height in multiples of standard unit size. All auxiliary devices for control, indication, measurement and protection except the bimetallic relays shall be mounted on the front side of the respective compartment. Components requiring frequent inspection during operation shall be easily accessible. Panel shall be SCADA compatible.

7.2 Constructional Features

The Panel shall be sheet steel clad with the frame fabricated out of 2 mm CRCA sheet steel and doors/cover out of at least 1.6 mm CRCA sheet steel.

All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All floor mounted panels shall be provided with a channel base frame. Total height of all floor mounted panels shall not be greater than 2300 mm. Panel shall be dust and vermin proof. Degree of protection of the enclosure shall be IP 42 for indoor installations and IP 55 with rain canopy for outdoor installations.

Metal clad cubicles/modules shall be provided with hinged doors in the front, with facility for padlocking door handles. More than one module may be arranged in the same vertical section. Circuits shall be of the fixed type. The switchboard enclosure shall conform to "Form - 4" as per IS-8623. It shall be possible to extend the switchboard on both sides.

The fixed type module shall have all the circuit components mounted in the compartment, with bolted type power and control connections. It shall be possible to remove all circuit components after removing the connections and the component fixing bolts. Instruments, relays and control devices shall be mounted flush on hinged door of the cubicles. Switchboard shall be complete with inter-panel wiring.

Panel shall also be fitted with a label indicating its title. Each cubicle shall be fitted with a label on the front and rear of the cubicle. Each relay, instrument, switch, contactor and MCCB/MCB shall be provided with a separate label. One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal bus bar compartment. However, each shipping sections shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

7.3 Bus-Bar

The bus bars shall be suitable for 4 wire, 415 volts, 50 Hz system and shall be made of high conductivity electricity conductor grade electrolytic AL 91E. In case of copper bus

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bar it shall be electrically conductor grade electrolytic copper and at the time of joining of two copper buses tinning will be done on the copper strips ends to a length equal to the lap length of the joint plus one each. The phase and neutral bus bars shall be of rating indicated in the corresponding BOQ/one line diagram. The bus bars shall have uniform cross section throughout and shall be provided with minimum clearances as specified in relevant IS.

The bus bars shall be capable of carrying the rated current at 415 volts continuously and will run in a separate bus bar chamber All bus bars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colors to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

Bus bar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Bus bars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint. Direct access to, or accidental contact with bus bars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of bus bars due to insertion of maintenance tools. Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

7.4 Air Circuit Breaker

i. General

Air circuit Breaker shall comply with latest IEC/IS standards. All four pole Breaker shall be capable of setting Neutral Protection to N or N/2 to ensure precise neutral Protection. Breaking Capacity of Breaker in Panel shall be $I_{cs} = I_{cu}$ at 440V & $I_{cs} = I_{cu} = I_{cw}$ (for 1sec). All ACB shall have Fault indication LEDs on release.

ACB shall have indication of Mechanical wear of Contacts, enabling visible indication of Contact life. All ACBs should have the moulded case design with class 2 front facia. The accessories like shunt trip, closing trip coils should be continuously rated to avoid the Burning due to sustained command.

ii. Operating Mechanism

ACB shall be EDO type. The operating mechanism shall be of the Open/Closed/Open stored-energy type. The closing springs shall be able to be manually charged by operating the front lever. The circuit breaker shall be of trip free type and shall be provided with built-in mechanical Anti Pumping device. Closing coil & other auxiliary devices shall be available in sufficient number for the purpose of indication, alarms, annunciations on switch boards as well as on respective remote control panel in control room & for the purpose of interlocking scheme shall be provided

There shall be four distinct & separate position of the circuit breakers on the cradle as – Service / Test / Isolated / Maintenance. The first three positions shall be positively

achieved only through the racking motion of draw out mechanism & not by trail & error. There shall be indicator clearly showing the above 3 conditions.

iii. Protection & Measurement Function

All ACBs shall have microprocessor based releases capable of sensing true rms value of current based on digital technology. Protection unit shall offer following as standard in all breakers excluding bus couplers: Long-time protection with adjustable time delay. Instantaneous or Short circuit protection with time delay. The short circuit setting (I_{sd}) should necessarily be the function of the set current (I_r) of the ACB. The instantaneous protection shall have the option of OFF position in case of certain conditions of discrimination. Earth fault protection with adjustable current and time setting along with separate adjustable setting for instantaneous short circuit protection.

All the adjustments should be on line & the circuit breaker need not be switched off while adjusting the settings.

The control unit shall have thermal memory for repetitive over current faults for protecting the cables & loads. Breaker shall have facility of Zone selective interlocking without needing any external control supply.

7.5 Moulded Case Circuit Breaker (MCCB)

MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing. MCCBs shall have an ultimate short circuit capacity not less than the prospective short circuit current at the point of installation.

MCCBs shall have a service short circuit breaking capacity equal to the ultimate short-circuits capacity. Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable (70-100%). Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated. The MCCBs shall be provided with the following features:

- (i) Common trip bar for simultaneous tripping of all poles.
- (ii) Shrouded terminals
- (iii) Time for clearing short circuit current of 20 msec.
- (iv) 2 NO + 2 NC auxiliary contacts

7.6 Miniature Circuit Breaker (MCB)

MCB shall be hand operated, air break, quick make, quick break type. Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

7.7 Contactor

The power contactors used in the panel shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947. Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage.

Contactors shall be provided with a two element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP). Motor starters shall be complete with auxiliary relays, timers and necessary indications.

7.8 Instrument Transformer

Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current. CT core laminations shall be of high grade silicon steel. Secondary winding of voltage transformer (VT) shall be rated for a two phase line to line voltage of 110 V. Identification labels giving type, ratio, output and serial numbers shall be provided.

7.9 Relay

Main protective relays shall be Numerical / Static type. All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting. All relays shall be accessible from the front for setting and resetting. Access to setting devices shall be possible only after the front covers of the relays are removed. Resetting facilities shall however be accessible external to the relay case. All protective relays shall be of the draw-out type and shall be provided with operation indicators visible from the front. Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage.

7.10 Soft Starter & VFD

Soft Starter and VFD may or may not be integral part of LT Panel as required. Specification of Soft Starter & VFD is given separately.

7.11 Control and Selector Switch

Control and selector switches shall be of the rotary type, having enclosed contacts, which are accessible by the removal of the cover. Control and selector switches for instruments shall be flush mounted on the front of the panels and desks. All control switches shall be of the spring return to normal type and shall have momentary contacts. Selector switches shall be of the stay-put, maintained contact type.

7.12 Indicating Instrument & Meter

All indicating Instruments shall be flush mounting 96x96 mm digital type with accuracy class 1.0 and RS 485 communicable port for direct connection to SCADA using the

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Modbus protocol. Digital multi-function meter shall indicate following parameters; V, A, F, PF, KW, KVA, KVAR, KWh, KVAh, KVARh, run hours, on hours, Phase angle, interrupts, THD, events, neutral current.

7.13 Indicating Lamp

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

7.14 Push Button

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head. Colours of push buttons shall generally comply with IS6875, BSEN 60947, 60 0 37 or IEC 60073.

7.15 Space Heater

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 45° C.

7.16 Cubicle Lighting/Receptacle

Each control panel, control cabinet, marshalling box, etc. shall be provided with interior lighting by means of a CFL/LED lighting fixture. A Miniature Circuit Breaker (MCB) shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB for connection of hand lamp.

7.17 Safety Arrangement

All terminals, connections and other components, which may be "live" when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labelled to facilitate testing.

7.18 Power and Control Cable Termination

Equipment terminal blocks for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables. Double compression type cable glands shall be provided for all power and control cables. Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding a high voltage test of 3000 V for one minute.

7.19 Wiring for Control and Protective Circuit

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All wiring for control, protection and indication circuits shall be carried out with 650 V grade, FRLS PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm. All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. All wiring shall be taken to terminal blocks without joints or tees in their runs. All wiring shall be colour coded as given below:

- (a) Instrument Transformer : Red, Yellow or Blue determined by the
Circuit phase with which the wire is associated
- (b) A C phase wire : White
- (c) A C neutral : Black
- (d) D C circuits : Grey
- (e) Earth connections : Green

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels. Ferrules shall fit tightly on wires, without falling off when the wire is removed. Ferrules shall be of yellow colour with black lettering.

All wires forming part of a tripping circuit shall be provided with an additional red ferrule marked 'T'. Each wire shall be identified by a letter to denote its function followed by a number to denote its identity, at both ends. Unused core of multicore cables shall be ferruled U1, U2 etc., at both ends, and connected to spare terminals. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

7.20 Control Wiring Terminal Block

Terminal blocks shall be of the 650 V grade and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

Terminals shall be numbered for identification, grouped according to function. Engraved 'black on-white' labels shall be provided on the terminal blocks describing the function of the circuit. Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled.

Terminals used for connecting current transformer secondary leads shall be 'disconnecting and shorting' type with a facility grounding the secondary.

Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring relatively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

Test terminal blocks, if any, shall be provided for secondary injection and testing of relays. A suitable metering block shall be provided where specified for the connection of a portable precision instrument to be operated when required for specific plant testing purposes.

7.21 Earthing of Panel

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Each panel shall be provided with an earth bus bar running along its entire length. The earth bus bar shall be located at the bottom of the panel. Earth bus bar shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated panel.

Positive connection of the frames of all the equipment mounted in the panel to the earth bus bar shall be maintained through insulated conductor of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth bus bar by means of 650 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

7.22 Interface with PLC/SCADA System

LT Panel shall be wired for interface with PLC and SCADA. Individual starters shall be wired to a common marshalling compartment in LT panel. 1 no. marshalling compartment shall be provided for each transport section of LT Panel. Multi-core cables shall run from marshalling compartment to the PLC and SCADA system.

7.23 Technical Particulars

The specific technical particulars of the panel shall be as given below:

Ser No	Description	Particulars
1.	Rated voltage, Phases and Frequency	433 V, 3 Ph, 50 Hz
2.	Type of Construction	Single front, fixed type (except for ACB)
3.	Maximum system voltage	476 V
4.	One minute Power Frequency withstand voltage	
a)	Power circuit	3000 V (rms)
b)	Control Circuit	2000 V (rms)
5.	Auxiliary circuit connection to secondary of CTs	2000 V (rms)
6.	Current rating of busbars over design ambient temperature of 45oC	(*)
7.	Short circuit withstand for main and auxiliary busbars (1 sec.)	(*)
8.	Maximum temperature of main and auxiliary busbars at continuous rated current rating under site design ambient temperature of 45degree C	85 degree C
9.	Colour finish shade as per IS:5	
10.	Interior	Glossy white
11.	Exterior	Light grey, semi-glossy, shade 631 of IS 5
12.	Earthing bus material and size	Copper, 25 x 6 mm
13.	Clearances in air of live parts	25.4 mm
14.	Power contactors	
a)	Contactor rated duty	AC3

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Ser No	Description	Particulars
b)	Utilisation category	Uninterrupted
15.	Motor Starters	Auto Transformer, Star-Delta, DOL Starters
18.	Type of Mounting	Floor
19.	Cable Entry	(*)

(*) To be worked out by the contractor based on approved calculations submitted by the contractor.

8. CAPACITOR & CAPACITOR PANEL

8.1 Codes and Standards

Title	Code No.
Shunt capacitors for power systems	IS : 2834/BS1650
Internal fuses and internal overpressure disconnectors for shunt capacitors	IS : 12672
Metal enclosed switchgear	IS : 3427 / BSEN 60298 / IEC : 298
Control transformers for switchgear and controlgear voltage not exceeding 1000V AC	IS12021

8.2 Design Features

i. General

Capacitors shall comply with IS 2834 or BS 1650. Capacitors shall be sized to improve the Power Factor of the system to 0.995 lag. Adequate number of switching steps shall be provided to achieve the set power factor.

Capacitors shall be metal enclosed and be fitted with discharge resistors. Each capacitor shall bear a label clearly warning of the need to allow a discharge time after isolation prior to working on the capacitor. Capacitors for indoor use shall meet the requirements of IP 42. The contents of capacitors under normal operating or fault conditions shall not present a fire or health hazard.

Power capacitors and capacitor controls shall be housed in a metal enclosed cubicle and shall be constructed of cold rolled sheet steel of 2 mm thickness. Power capacitor shall be housed in the lower/rear compartment and capacitor controls in the top/front compartment. The assembly of the capacitor banks shall be such that it provides sufficient ventilation for each unit. Each capacitor case and panel shall be earthed to a separate earth bus.

ii. Capacitors

Capacitors shall be two layer dielectric design of film + paper + foil (MD) or metallised polypropylene (MPP), minimum thickness of film shall be 16 micron with internal fuses for each element, completely impregnated with non-PCB, non-toxic, non-inflammable oil and shall be hermetically sealed. Bushings may be either of glass or porcelain and shall be joined to the case by solder-welded or other method which ensures an adequate and permanent seal.

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Each capacitor unit / bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.

Each capacitor unit shall satisfactorily operate at 135% of rated kVAR including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10% above rated voltage excluding transients.

Capacitor units shall be provided with terminal covers to enclose live parts. In case of banks, base channel to mount the capacitors, common terminal cover and a set of aluminium bus bars shall be provided. A weather-proof and corrosion-proof name plate shall be provided on each capacitor unit. The nameplate shall contain the information set out in IS: 2834.

The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not. The capacitors bank may comprise suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series rack shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units.

The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers shall be provided in the cubicle to ensure proper ventilation. Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle.

iii. Rated Voltage

Rated voltage for use in LV (415 V) system, where there are no non-linear loads, shall be 440 V and the rated for capacitors, where non-linear loads and hence harmonics are present, the rated voltage shall be 525 V.

iv. Rated output (kVAr)

The kVAr output of the capacitors, as calculated in PF correction calculations, shall be at 415 V. The kVAr output at 440 V or 525 V shall be proportional (in square) to the rated voltage.

v. Series Reactors/ Detuned filters

For system with linear loads i.e. without presence of harmonics, the capacitor banks shall be provided with 1% series reactors. The reactor design shall be such that they will not be over loaded due to harmonics in the supply system. The series reactor shall suppress the capacitor charging in-rush current to a safe value for the capacitor as well as for rest of the system. For system with non-linear loads i.e. with presence of harmonics, the capacitor banks shall be provided with 7% detuned filters to protect the capacitors from effect of harmonics. The detuned filters shall be protected themselves adequately against overheating by way of a temperature switch.

8.3 Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the

fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. A blown fuse shall give visual indication so that it may be detected during periodic inspection. The fuse blowing time shall coordinate with the pressure built up within the unit to avoid explosion.

8.4 Capacitor Control Requirements

Capacitor control relays shall be used for step control of low voltage capacitors. The relay shall be of digital design so that it can select any combination of unequal kVAR steps to achieve desired PF.

The power factor relay shall comprise a single/three phase electronic measuring circuit sensitive to power factor and/or reactive load and shall be used to control power factor improvement capacitors in discrete stages. Number of steps shall be adequate to control capacitor units connected to the same bus as that of the relay as well as control capacitor units connected to the other bus in case it is required to do so. Alternatively, a summation CTs based scheme shall be used for 2 incomers + 1 bus coupler configuration.

The relay shall be operative above a pre-set minimum current/ reactive kVAR and shall initiate corrective action above this value only. The Automatic Power Factor Correction (APFC) relay shall also have built-in time delay feature to prevent re-switching of a capacitor which has just been switched off, to avoid damage to the capacitor. Capacitor control shall be either manual or automatic by way of a selector switch. The relay shall be provided with LEDs to indicate the number of stages in operation. It shall provide a set point facility for required system power factor and shall give a continuous display of system power factor. A sensitivity (dead band) feature shall be provided to prevent 'hunting' of the relay. Contactors used for control of capacitors – for switching 'On' & 'Off' – shall be suitable for 'capacitor duty'.

Control Requirements for Capacitor Control Panel

The capacitor control panel shall be complete with

- Sequencing devices, timer and auxiliary relays for automatic sequential switching of the capacitors in and out of circuit.
- Auto-Manual selector switches
- Push buttons for switching 'On' and 'Off' of individual capacitor units in manual mode.
- Red and green lamps for capacitors ON/OFF indication.

8.5 Tests and Test Reports

All Routine Tests according to IS shall be carried out on completely assembled capacitor units and capacitor control panels at the manufacturer's Works and the same shall be witnessed by the Employer's Representative.

8.6 Rating Plate

Information according to relevant standard shall be given on the rating plate of each capacitor unit.

9. DG SYNCHRONIZATION PANEL

9.1 Scope

This section covers design, manufacture, inspection, transportation to site, installation, testing and commissioning of DG Synchronization Panel for running of DG Set in parallel i.e. their synchronization on common bus bar, auto load sharing and auto load management.

The construction features of this Panel and their component shall be governed by the technical specification of LT Panel as described in previous section.

9.2 General

The operation of DG Set shall be monitored and controlled by this PLC based logic Panel. In case of mains failure, this logic panel shall control auto changeover from mains to DG Sets supply and interlocking of MCCB/ACB, auto synchronizing and auto load management functions.

The panel shall be provided with a total manual over ride facility. The panel shall be complete with all Auxiliary relays, timers, contactor, PLC, control wiring, interconnections etc.

9.3 Control Philosophy

i. Automatic Start & Stop of Engine

The system should come in operation after sensing of grid failure and automatically control the start & stop of engines, depending on the predefined load setting in the PLC.

ii. Automatic Synchronization

The facility of synchronization will be available in both Auto & Manual mode. In normal circumstances the auto synchronization will work, however if due to any reason auto synchronization fails repeatedly the facility for closure of MCCB/ACB must be available automatically. In manual mode MCCB/ACB will be closed by panel push button.

iii. Automatic Load Sharing

The load sharing will also be automatic by sensing both active & reactive power.

iv. Back Up Protection

The system should also have following in built protection other than external relays in synchronization panel:

Reverse power, reverse KVAR, over current, under current, over voltage, under frequency, over frequency, synchro check & earth fault relay except differential relay. Due to any electrical fault PLC shall trigger the master trip relay.

9.4 Sequence of Operation

The following sequence of operation shall be achieved through PLC based logic panel in addition to hardware interlocks as well as software interlocks:

- (a) Selection of any generator as a lead generator to achieve the uniform running hours of all generators.

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- (b) Three attempts to start the engine of lead generator. In case the engine fails to start or does not achieve the requisite speed within the predetermined time, PLC system declares engine of generator faulty. In this event PLC automatically selects next generator as the lead generator.
- (c) The PLC system automatically selects starting sequence of other generators on the basis of the lead generator being selected by the operator.
- (d) Before issuing close command to lead generator ACB/MCCB, PLC checks that ACB/MCCB of any generator is not in close position. Then PLC system gives close command to lead generator ACB/MCCB. The PLC system tries two times with interval of 5 secs to close the ACB/MCCB. Simultaneously, it also gives starting command to next generator engine in queue depending upon load.
- (e) The speed, excitation, frequency and voltage of incoming generator are controlled identically as per the lead generator starting sequence described above, except closing of ACB/MCCB.
- (f) When the lead generator KW crosses more than the 85% of rated capacity of DG set, the PLC system performs synchronization sequence for paralleling of generator prior to switching on the ACB/MCCB of 2nd generator.
- (g) The last incoming generator ACB/MCCB is tripped when PLC system senses that the total load on the system is less than the specified load and stops the engine after 5 minutes of idle running.
- (h) DG sets will start and stop automatically depending on the pre-defined load setting in the PLC & also all DG sets will operate in load sharing mode.

10. 415 V SILENT DIESEL GENERATING (DG) SET

10.1 General

Scope includes supply, installation, testing and commissioning of water cooled turbo charged silent Diesel Generating set (CPCB norms compliance) mounted and aligned on a common M.S. base frame complete with M.S. fuel tank, Engine control panel, AMF Panel, residential exhaust Silencer, AVM pads fitted on base frame, battery & battery leads, 1st fill of lube oil and all housed in sound proof acoustic enclosure with 4 no's earthing complete in all respects and as required at site.

10.2 Engine

The water cooled engine shall conform to IS-10002/BS-5514/DIN-6271/ISO-3046 at 1500 RPM capable of running the coupled alternator under conditions specified therein. The Engine shall be fitted with following accessories subject to the design of the manufacturer:

- a) Dynamically balanced Flywheel.
- b) Necessary flexible coupling and guard for alternator and engine (applicable only for double bearing alternator).
- c) Air cleaner (dry/oil bath type) as per manufacturer standard.
- d) A mechanical/electronic governor to maintain engine speed at all conditions of load.
- e) Daily fuel service tank of suitable capacity fabricated from MS sheet with inlet, outlet connections air vent tap, drain plug and level indicator (gauge), MS fuel piping from tank to engine with valves, unions, reducers, flexible hose connection and floor mounted pedestals, twin fuel filters and fuel injectors.
- f) Dry exhaust manifold with suitable exhaust residential grade silencer to reduce the noise level.

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- g) Suitable self-starter for 12 V/ 24 V DC
- h) Battery charging alternator unit and voltage regulator, suitable for starting batteries, battery racks with interconnecting leads and terminals.
- i) Necessary gear driven oil pump for lubricating oil, priming of engine bearing as well as fuel systems as per manufacturer recommendation.
- j) Naturally aspirated/turbo charger (as per manufacturer standard)
- k) Lubrication oil cooler
- l) Lubrication oil filters with replaceable elements
- m) Crank case heater as per manufacturer recommendations
- n) Fuel injection, Fuel control solenoid, Fuel pump with engine speed adjustment
- o) Engine Control Panel: fitted and having digital display for following;
 - i) Start/Stop key switch
 - ii) Lube oil pressure indication
 - iii) Water temp. Indication
 - iv) RPM indication
 - v) Engine hours indications
 - vi) Battery charging indication
 - vii) Low lube. Oil trip indication
 - viii) High water temp. Indication
 - ix) Over speed indication
- p) All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch any moving part.
- q) Radiator/Heat Exchanger System / Remote Radiator
- r) Any other item not included / specified but is a standard design of the manufacturer
- s) Engine Operation/ Maintenance & Spare Parts Manual
- t) Loading permitted 110% for 1 Hr. once in every 12 hrs.
- u) Engine Warranty Certificate
- v) Engine test certificate
- w) The engine should be of as per list of approved make.

10.3 Alternator

Self-excited, screen protected, self-regulated, brushless alternator, horizontal foot mounted in single/double bearing construction suitable for the following;

- a) Rated PF : 0.8
- b) Rated Voltage : 415 V
- c) Rated Frequency : 50 Hz
- d) No. of Phases : 3
- e) Enclosure : SPDP
- f) Degree of Protection : IP-23
- g) Ventilation : Self ventilated air cooled
- h) Insulation Class : F/H
- i) Temperature Rise : within class F/H limits at rated load
- j) Voltage Regulation : +/- 1 %
- k) Voltage Variation : +/- 5 %
- l) Overload duration/Capacity: 10% for 1 hr. in every 12 hrs. of continuous use
- m) Frequency Variation : As defined by the Engine Governor (+/- 1%)
- n) Excitation : Self (up to 750 KVA/ separately excited (>750)
- o) Type of AVR : Electronic
- p) Type of bearing & lubrication: Anti-friction bearings with grease lubrication
- q) Standard : IS 4722 & IEC: 34 as amended up to date

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Alternator should be able to deliver output rating at actual site conditions. The alternator above 500 KVA shall be fitted with suitable No's Resistance Temperature Device (RTD) & Bearing Temperature Device (BTD) along with space heaters. The terminal of space heaters will be wired to terminal box and the temperature scanner shall be provided in control panel for scaling the winding and bearing temperature.

10.4 Essential Accessories

One set of the following essential accessories shall be supplied with DG set. This set of accessories shall be housed inside the enclosure;

- a) One No. M.S. base frame suitable for mounting of the offered engine and alternator.
- b) One No. inbuilt Daily fuel tank of suitable capacity complete with fuel gauge, inlet/ outlet connections, drain plug etc.
- c) Suitable Dry type Batteries of Approved Makes with leads and terminals shall be part of the equipment. The pack shall be suitably positioned and modular withdraw able for ease of servicing. The Battery pack shall be minimum 180 AH.
- d) 1 Set of AVM Pads fitted on Base Frame.

10.5 Base Plate

Sturdy, fabricated / welded construction, made out of high quality steel section suitable for mounting the engine and alternator. The base frame shall be suitably designed to simplify transportation, handling, slinging, erection and commissioning shall have provision for levelling adjustments, as required during installation. Engine and alternator should be directly coupled through a set of flexible couplings and mounted on a common fabricated base plate.

10.6 Auto Mains Failure (AMF) Panel

The AMF Panel shall be fabricated from 2mm thick sheet steel, powder coated, totally enclosed, dust, damp and vermin proof, free standing, floor mounted type & front operated. The degree of protection will be IP-42 conforming to IS 2147. Panel shall include the following:-

- a) Control system equipment's and components such as relays, contactor, timer etc. both for automatic operation on main failure and as well as for manual operation.
- b) Necessary instruments and accessories such as voltmeter, Ammeter, PF meter, KW & KWH meter, frequency meter etc. in one energy analyser unit with selector switch.
- c) Necessary indicating lamps, fuses, terminal blocks, push button, control switch etc. as required.
- d) Electronic hooter, Visual & Alarm indication for faults, UPS.
- e) ACB/MCCB, Battery charger etc.

10.7 Acoustic Enclosure

- a) The acoustic enclosure shall be designed and manufactured conforming to relevant standards suitable for outdoor installation exposed to weather conditions and to limit overall noise level to 75 dB (A) at a distance of 1 mtr. from the enclosure as per CPCB norms under free field conditions.

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- b) The construction should be such that it prevents entry of rain water splashing into the enclosure.
- c) The enclosure shall be fabricated out of the CRCA sheet of thickness not less than 1.6 mm on the outside cover with inside cover having not less than 0.6 mm thick perforated powder coated CRCA sheet.
- d) The hinged door shall be made from not less than 16 SWG thick CRCA sheet and will be made air tight with neoprene rubber gasket and heavy duty locks.
- e) All sheet metals parts should be processed through 7 tank process.
- f) The enclosure should be powder coated.
- g) The enclosure should accommodate the daily service fuel tank with provision of fuel gauge. The fuel tank should be filled from the outside as in automobiles and should be with a lockable cap.
- h) The batteries should be with accommodated in the enclosure in battery rack.
- i) The canopy should be provided with high enclosure temperature safety device.
- j) The acoustic lining should be made up of high quality insulation material i.e. rock wool /glass/mineral wool/PU foam of appropriate thickness & density for sound absorption to reduce the sound level as per CPCB norms. The insulation shall be covered with fine glass fibre cloth and would be supplied by perforated MS sheet duly powder coated / GI sheet / aluminium sheet.
- k) The enclosure shall be provided with suitable size & No. of hinged type doors along the length of the enclosure on each side for easy access inside the acoustic enclosure for inspection, operation and maintenance purpose. Sufficient space will be provided inside the enclosure on all sides of the DG set for inspection, easy maintenance & repairs.
- l) The canopy should be as compact as possible with good aesthetic look.
- m) The complete enclosure shall be of modular construction.
- n) The forced ventilation shall be as per manufacturer design using either engine radiator fan or additional blower fans.
- o) The acoustic enclosure should be suitable for cable connection / connection through bus-trunking. Such arrangements on acoustic enclosure should be water proof & dust-proof conforming to IP-65 protection.
- p) The inside of enclosure should be provided with at least 2 No's 28W T5 fluorescent tube light luminaire.

11. 415 V SOFT STARTER

The Scope includes supply, installation, testing and commissioning of 415 V Soft Starters as per applicable standard and having following specifications:

11.1 Construction

The construction features of this Panel shall be governed by the technical specification of LT Panel as described in previous section.

11.2 Design

Soft starters for 415 V application shall be electronic/digital type. The soft starters shall enable smooth acceleration of motor and shall be universal in design. It shall be compatible with any make of the motor and its performance shall not be dependent on the design of the motor. The soft starters shall be provided with bypass facility, either

built into the soft starter or with the help of an external contactor adequately rated. Bypass shall be effected once the motor has successfully picked up. Bypass of the soft starters, however, shall not make the inherent motor protections built into it. In case, bypass contactor bypasses the soft starter completely, external protections by way of electronic motor protection relays shall be provided. Control circuit shall ensure that the motor is not switched 'On' with the bypass contactor 'On'. The soft starter shall have communication facility with PLC/SCADA. The soft starter shall have self-diagnostic feature and shall annunciate failure/ trouble with the soft starter.

11.3 Performance

i. Rated current

The Soft Starter shall have nominal current rating of 1.3 times the full load current of the controlled motor for standard duty applications. (Standard duty applications are those which do not exceed 240 seconds at 3 times the motor nominal current per hour including starting, stopping or braking.)

For severe duty applications such as centrifugal blowers, the Soft Starter should be de-rated to suit the requirements of the application. The manufacturer shall state the nominal current ratings of the Soft Starter in such cases. In the case of the ambient temperature exceeding design temperature around the soft starter, the soft starter should be de-rated suitably.

ii. Current Limit Range

The Manufacturer shall specify the current limit range of his proposed Soft Starter.

iii. Operating Characteristics

The Soft Starter shall comply to the following operating characteristics:

Allow the output limit current to be adjusted from 150 to 600% of the nominal current rating of the Soft Starter. Allow adjustable acceleration times up to 60 seconds.

iv. Soft Starter Protections

Protections should be provided as specified below:

Thermal replica types overload protection, Protection against single phasing, excessive negative phase sequence currents, reverse phase sequence in supply, Earth faults and stalled rotor protection Fuses should be supplied for type 2 co-ordination. These should be of the fast acting 'semiconductor grade' for protection of the Thyristors.

v. Motor Thermal Protection

Thermal overload protection should be integrated in the Soft Starter and should be adjustable according to thermal class of the application.

vi. Start time too long

The Soft Starter should supply protection against start times exceeding the programmed start time in the case of overloads at starting.

11.4 Indications and Alarms

A fault history for soft starter protection functions shall be provided for fault indication and fault tracing. Fault indication shall be displayed in plain text on an alphanumeric display.

11.5 Operator Controls

The Soft Starter should be provided with local and remote control functions.

11.6 Local Control

A control panel shall be mounted on the front of the enclosure provided with operation functions.

11.7 Remote Control

Provisions shall be included for the Soft Starter to be controlled remotely. Necessary terminals for the input and output functions shall be provided. When the control function is changed from local to remote or the reverse the adjustments of the Soft Starter shall be maintained.

The following functions shall be provided:

Uploading and downloading of pre-set parameters to the PC, Locking and unlocking parameter settings to prevent unauthorized access.

11.8 Instruments and Meters

All required instruments and meters, control and selector switches, push buttons and indicating lamps shall be provided.

11.9 Analogue and Digital I/O

Digital and Analogue inputs and outputs shall be fully programmable and shall be galvanically isolated. The function for scaling of analogue output shall be fully programmable. Facilities for selection of signal range from 0 to 20mA, 4 to 20mA, 0 to 10V or 2 to 10V shall be provided.

11.10 Cable Connections

Terminal blocks provided shall be segregated according to circuit voltage and field destination.

11.11 Wiring

All wires for electronics and signals should be shielded and should be at least 0.5mm².

11.12 Earthing

Earthing shall be provided as per manufacturer standard.

11.13 Rating Plates and Labels

The Soft Starter shall have a rating plate permanently fixed to the front of the equipment giving relevant information as per Standards and as per Manufacturer's standard.

12. VARIABLE FREQUENCY DRIVE (VFD)

12.1 General

The Scope includes supply, installation, testing and commissioning of VFD as per IEC 1800-2 or EN 61800-2 which is the “General Requirement for Variable Speed Electrical Power Drives – Product Standard” and other applicable standard.

12.2 Assemblies

i. Incoming Isolation and VFD Safety Devices

The frequency controller, when mounted in an enclosure, shall be provided with an incoming isolating device such as Moulded Case Circuit Breaker or Air Circuit Breaker depending upon rating of the VFD. Local isolation as above is essential for safety of operating personnel.

In addition, appropriately rated semiconductor grade fuses shall be provided for protection of the semiconductors in the VFD. The power supply facility will not have this protection built into it.

ii. Cooling

The VFD itself shall be provided with its own cooling fan integral to the heat sink of the unit. In addition, the enclosure of the VFD shall be provided with a cooling fan of adequate capacity for maintaining temperature of the enclosure within the permissible limits. Louvers meant for fresh air intake shall be covered with fine wire mesh or foam filter to prevent ingress of dust.

Effective operation of enclosure cooling fan shall be monitored by any one of the following methods;

Using undercurrent relay sensing failure of the cooling fan, using an air flow switch mounted on the cooling fan ensuring proper operation of the fan.

Failure of enclosure cooling fan shall be annunciate on SCADA/ remote control system. Failure of integral cooling fan, which results into over-temperature of the heat sink shall trip the VFD with an appropriate annunciation in the operator interface module.

iii. Enclosure

The degree of protection shall be IP42 minimum. The controller must have adequate free space around it to permit good air flow for cooling purposes.

12.3 Type of Converter

The type of Inverter shall be suitable for controlling the speed of standard AC squirrel cage induction motors. This shall be of latest technology, IGBT based, with high frequency switching (switching frequency less than 4 kHz), based on PWM principle, producing a near-sinusoidal waveform in the output.

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The Inverter shall include power conversion components, power control logic devices and regulator circuitry. The VFD panel is likely to be installed in an AC environment. However, under site operating conditions, the electronics (PCBs) may still be subject to highly corrosive gases such as H₂S. For this purpose, the PCBs shall be provided with special anti-corrosive coating

The regulator shall be fully digital with a microprocessor controlling the output frequency, voltage and current. The Power Rectifier should be 6 or 12 pulse operation.

12.4 Performance

i. Rated current

The converter shall have a current rating that is at least equal to the full load current of the controlled motor with a margin of 10%. In case of low inertia loads such as pumps etc. 'Normal duty' rating of the VFD shall be applicable while for high inertial loads 'Heavy duty' rating shall be applicable. The supplier of VFD shall declare both 'normal duty' as well as 'heavy duty' ratings of VFDs offered by him and select appropriate rating for the VFD.

ii. Input Filter/ Harmonic mitigation

The converter should be equipped with an Input and/or DC choke or low EMC filter to reduce the harmonics on the supply side. The overall design shall be "Low Harmonic" type. Refer to IEC1800-3 or (EN61800-3) which states the Variable Speed Drive product standard relating to electromagnetic compatibility.

iii. Output Overvoltage Control

As required by the application and based on VFD manufacturer's standard, an output side choke shall be provided for protection of motors from overvoltage in case the output cable length exceeds the acceptable value.

iv. Current Limit Range

The Variable Speed Drive current limit should be variable to a maximum value of at least 150% of the drive rated current.

v. Speed Control Range

The drive shall have sufficient capacity to provide speed control of the motor throughout the applications' operating range.

12.5 Operating Characteristics

The VFD shall comply with the following operating characteristics:

- Allow a maximum current of 1.5 x the rated current for a maximum of 60 seconds at rated motor frequency.
- Frequency resolution of 0.1%
- Electronic bi-directional operation
- Greater than 95% efficiency at full load and speed
- A minimum incoming line power factor throughout the load and speed range of 0.95

12.6 Protections

The VFD shall provide following protections to the drive motor:

- Motor Thermal Protection (49) should take the speed and cooling (forced or self-cooled motor) into account and shall provide thermal protection under both “Hot” and “Cold” condition.
- Motor Locked Rotor Protection (50 LR)
- Motor Negative Phase Sequence Overcurrent (which includes single phasing) protection (46)
- Motor circuit Earth Fault Protection (50N or 50G)
- Motor Short Circuit Protection (50) should be provided on the output of the drive against short circuits between phases and between phases and earth.
- Where thermistor probes/ RTDs are integrated into the motor, they shall be fed back as an input to the drive.

In addition, the VFD itself shall be provided with following protections:

Supply under voltage/ failure, Supply voltage unbalance/ single phasing, VFD (heat sink) over-temperature.

12.7 Operator Interface Module

An operator interface module (key pad) shall be provided for each VFD. This shall provide setting and programming facility for the VFD. The interface module shall also provide display of important operating parameters of the VFD as well as alarm functions. The key pad portion and the display shall be available on the enclosure door for easy access.

Indications and Alarms on Operator Interface Module:

A fault history for drive protection functions shall be provided for fault indication and fault tracing. Fault indication shall be displayed in plain text on an alphanumeric display.

In addition to the above fault indications, the following parameters shall be indicated on the display in the normal operating mode:

Frequency Set point (Hz), Output Frequency (Hz), Motor Speed (RPM), Motor Current (Amps), Calculated Motor Power (kW), Mains Voltage.

12.8 Operator Controls

The frequency converter should be provided with local and remote control functions.

Local Control: As mentioned above, a local operator interface panel shall be mounted on the front of the enclosure provided with required operation functions.

Remote Control: Provisions shall be included for the VFD to be controlled remotely. This may be via DIs & DOs and AIs & AOs. Necessary terminals for the input and output functions shall be provided. The remote control may also be obtained via a soft link over RS 485 or suitable protocol, for direct communication with the SCADA system.

When the control function is changed from local to remote or the reverse, the adjustments of the frequency converter shall be maintained.

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The following functions shall be provided:

Uploading and downloading of pre-set parameters to a PC, Locking and unlocking parameter settings to prevent unauthorised access.

12.9 Instruments and Meters

All required instruments and meters, control and selector switches, push buttons and indicating lamps shall be provided.

12.10 Analogue and Digital I/O

Digital inputs and outputs shall be fully programmable and shall be galvanically isolated.

The function for scaling of analogue inputs and outputs shall be fully programmable. Facilities for selection of signal range from 0 to 20mA or 4 to 20mA or 0 to 10V or 2 to 10V shall be provided.

As a general requirement, following DIs is envisaged:

VFD 'On', VFD Trouble/Tripped, VFD in Remote Select

Following DOs are envisaged:

VFD Run (Single contact for On/Off control for 'maintained' type output and two contacts for momentary 'On', 'Off' output)

Following AIs are envisaged:

Proportional to Speed, Proportional to Current

Following AOs are envisaged; Proportional to Speed reference

12.11 Cable Connections

Provisions for required cabling and cable connections shall be made.

12.12 Wiring

All wires for electronics and low level signals should be shielded and should be at least 0.5mm.

12.13 Earthing

Grounds between the VFD, the motor and the cable shielding must have "high frequency" equi-potentiality. Cables, for this purpose, shall be either shielded type or 3 ½ core or 4 core as per VFD manufacturer's recommendation.

Panel mounted units shall contain an earth bar to which internal earthing conductors shall be terminated. The normal protective conductors PE (green and yellow) should be connected to the PE terminals on each controller.

12.14 Rating Plates and Labels

Rating plates, nameplates and labels shall have the following minimum information:

Rated voltage and frequency, Rated output capacity, Standard to which equipment conforms, Month and year of manufacture, Manufacturers name and address, Type and serial number, Degree of ingress protection.

13. INDUCTION MOTOR

13.1 Design requirements

The Motors shall generally conform to IS: 325, IS: 12615-2018 or relevant equivalent internationally approved standards.

13.2 Starting

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard). Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

13.3 Performance and Characteristics

Motor shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

Variation in supply voltage	+/- 10%
Variation in supply frequency	+/-5%
Combined voltage and frequency variation	+/-10%

Motor shall be suitable for full voltage direct-on-line starting and /or star delta starting.

13.4 Rated Output

The power output rating of the motor shall be larger of the following:

- 115% of the power input to the driven equipment – pump, blower etc. at duty point.
- 105% of the maximum power input to the driven equipment under any operating condition.

13.5 Energy Efficient Design

Motors shall be 'Energy Efficient' type IE3 according to IS-12615:2018. Where IE3 design of motor is not available with any of the approved suppliers of the motors, motors conforming to energy efficiency level IE2 will be considered as acceptable. Motors with lower energy efficiency level will not be accepted.

13.6 Insulation

The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

13.7 Motors for VFD application

Inverter duty motors shall be designed to withstand 1600 volts peak and rise time of >0.1 microsecond which shall be in accordance with NEMA standard MG-I. These motors shall offer increased winding slot insulation, increased first turn insulation and increased phase-to-phase turn insulation.

The stator winding shall be made from high conductivity annealed copper conductor, winding insulation shall be of class-F insulation, conforming to IS: 325. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII): 1970 for dry type motors.

13.8 Constructional Features

Motor weighing more than 25 Kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

13.9 Bearings

Motor shall be provided with antifriction bearings, unless sleeve bearings are required by the motor application. Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type are preferred. Bearings shall be provided with seals to prevent leakage of lubricant or entrance of foreign matters like dirt, water etc. into the bearing area.

Sleeve bearings shall be split type, ring oiled, with permanently aligned, close running shaft sleeves. Grease lubricated bearings shall be pre-lubricated and shall have provisions for in-service positive lubrication with drains to guard against over lubrication. Oiled bearing shall have an integral self cooled oil reservoir with oil ring inspection ports, oil sight glass with oil level marked for standstill and running conditions and oil fill and drain plugs.

Forced lubricated or water cooled bearing shall not be used without prior approval of Owner. Lubricant shall not deteriorate under all service conditions. The lubricant shall be limited to normally available types with IOC equivalent. Bearings shall be insulated for all HV motors and LV motors rated 90 kW & above to prevent shaft current and resultant bearing damage.

13.10 Terminal Box

Terminal boxes shall of weather proof construction designed for outdoor services. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase to ground clearances. Suitable cable lugs shall be supplied.

13.11 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

13.12 Space Heater

Motor of rating 30 KW and above shall be provided with space heaters, suitably located for easy removal or replacement.

The space heater shall be rated 240 V, 1 phase, 50 Hz and sized to maintain the motor internal temperature above dew point when the motor is idle.

13.13 Temperature Detectors

Five numbers of temperature detectors/thermistors shall be provided for LV motors above 90 kW (3 no's winding temps, 2 no's bearing temp.)

HV motors shall be provided with six RTDs in winding and 2 RTDs on bearings for indication and tripping of motor due to high winding and bearing temperature respectively. The RTDs shall be of 3 wire duplex type of platinum and embedded in the stator windings at locations where highest temperature is expected and embedded in each bearing. Terminals of RTDs shall be brought out in a separate terminal box located on the motor frame.

13.14 Accessory Terminal Box

All accessory equipment such as space heater, temperature detector, etc., shall be wired to and terminated in terminal boxes, separate from motor (power) terminal box.

14. UNINTERRUPTIBLE POWER SUPPLY (UPS)

The UPS shall be floor mounted, self-contained, metal clad and shall be suitable for operating on a nonlinear load. It shall be front door accessible.

The UPS system shall be true On-Line. The ON LINE UPS shall be incorporating a six-pulse rectifier and pulse width modulation inverter technology with 100% microprocessor control with built in static and manual bypass switch.

The UPS shall incorporate a DC under voltage trip circuit to electrically trip the UPS in order to protect the battery. The noise level of the unit shall not exceed 60dB (A) at 1m from the UPS cabinet. The output of the inverter shall be a sine wave having less than 5% THD for linear loads and less than 4% to 50% nonlinear load. It shall be suitable for load power factor 0.8 lag.

The unit shall have dynamic response such that a 100% step load causes an output voltage transient of less than $\pm 4\%$ with a recovery time of less than 4 ms. For three phase output units the output voltage shall not vary by more than $\pm 1\%$ for an unbalance for 10%. The load crest factor shall not be less than 3:1.

The efficiency at full load and 0.8 power factor shall be greater than 88%. Indicators to indicate; UPS status & UPS alarm conditions

The UPS shall provide a volt free contact output to indicate:

- Warning i.e. low battery capacity, Fault, Static bypass in use

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output. The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable

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for location adjacent to the UPS. The batteries shall be maintenance free lead acid type sealed for life. Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the buildup of gases.

Warning notices shall be provided for wall mounting to warn of the presence of charge gases. The battery supply of the UPS shall be via a fused load break switch dis-connector circuit breaker. The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load. The UPS battery shall have a backup of 120 minutes at full load and supported with inverter of suitable capacity.

15. LIGHTING SYSTEM

15.1 General

The contractor shall execute all works related to lighting system of WTP, pump house, buildings, roads etc. The contractor shall provide all indoor & outdoor LED lighting fixtures complete with driver, high mast for area lighting, ceiling fans, exhaust fan, receptacles, main lighting panel, lighting panels, RCCB, MCB, earthing, ACs for control room, office etc. and all other miscellaneous works required to fulfil the lighting system as per site requirement and as decided by Engineer-in-charge.

Illumination levels shall be maintained as per NLC guidelines.

All indoor & outdoor lighting fixtures shall be LED type suitable for operation on a nominal supply of 240 V, single phase, 50 Hz, AC with a voltage variation of +/- 10 %. Outdoor lighting fixture shall be weather-proof and rain proof type. All lighting fixtures shall have high efficiency driver, lumen output of more than 100 lum/watt, life of 50000 burning hours, surge protection, THD<10% and shall be designed for continuous trouble free operation and supplied with driver and all necessary accessories for their satisfactory operation. The fixtures shall be designed so as to facilitate easy maintenance including cleaning, replacement of component.

15.2 Lighting System of Buildings

Lighting system of Buildings includes the following work:

- (i) Cabling, conduiting, internal wiring, lighting fixtures (LED type), receptacles, ceiling & exhaust fan, lighting panels, other associated components and support material.
- (ii) LED light fixture shall be ceiling/ recess/ suspended mounted type made from CRCA sheet steel housing, high purity/ transmissivity diffuser for uniform light distribution.
- (iii) Earthing.

15.3 Area Lighting

Area lighting shall be done by high mast lighting system. High mast shall be hot dipped galvanized and consisting of lantern carriage for up to 12 nos. luminaries, mast head assembly, 2 nos. aviation obstruction lights, double drum type self-sustaining winch, integral power tool (winch motor with control circuit), lightening finial, suitable ropes

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and CC foundation of M-15 grade complete with Panel, internal cables, high power LED flood lights etc. as required. The mast shall be constructed from mild steel plates (as per BS-EN 10025) cut and folded to form a polygonal section, telescopic jointed and welding as per BS 5135. Number of high mast and its luminaires shall be worked out considering required lux levels throughout the outdoor area.

15.4 Street Lighting and Building Exterior Illumination

Street lighting LED luminaire shall be used for illumination of secondary roads, walkways, peripheral lighting of the premises, building exterior.

Building exterior illumination shall be done by LED street light fixture on single arm bracket mounted on building exterior wall.

Each lighting fixture shall be provided with an earthing terminal. All metal or metal enclosed parts of the housing shall be bonded and connected to the earth terminal to ensure satisfactory earthing continuity throughout the fixture.

16. EARTHING SYSTEM

16.1 Scope

The scope includes supply of earth electrode pits and earthing conductors and their installation including associated civil work as per the specifications and drawings, to the satisfaction of the Employer's representative and the Electrical Inspector. Proper earthing shall be provided to ensure adequate system neutral earthing and for equipment and personnel safety.

All work such as cutting, bending, supporting, painting/coating, drilling, welding, clamping, bolting and connection to structures, equipment frames, terminals, etc. shall be in the Contractor's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, welding rods, anti-corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.

16.2 Earthing System Installation

Earthing system shall conform to the latest edition of IS: 3043 and Indian Electricity Rules, 1956. All materials and fittings used in the earthing installation shall conform to the relevant Indian Standards and as approved by the Employer's Representative. Installation work shall be in accordance with approved earthing layout drawings and any change in routing, size of conductors etc. shall be subject to the prior approval of the Employer's Representative.

Metallic frames of all electrical equipment shall be earthed by two separate and distinct leads and then connected with earthing system in line with IE rules and IS-3043. Neutral points of transformers and DG set shall be earthed by two separate and distinct connections to two treated electrode pits. Crane rails shall also be connected to the earthing system. Cable sheaths and armour shall be bonded to the earthing system. Metal pipes and cable conduits shall be effectively bonded and earthed. Neutral connection shall never be used for equipment earthing.

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The scope of installation of earthing leads to the equipment and risers on steel structures/walls shall include laying the conductors, welding/cleating at specified intervals, welding to the main earth grids, risers, bolting at equipment terminals and coating welded joints by bituminous paint. Galvanized conductors shall be touched up with zinc-rich paint, when holes have to be drilled in them at site for bolting to equipment/structure.

The substation consisting of structure, transformer, fence and gate shall be properly earthed. Wherever earthing conductor crosses underground service duct and pipes, it shall be laid 300 mm below them. If the distance is less than 300 mm, the earthing conductor shall be bonded to such service ducts/pipes.

16.3 Earth Electrode Pits

Electrodes shall, as far as practicable, be embedded below permanent moisture level. Test pits with covers shall be provided for periodic testing of earth resistance. Installation of pipe electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil works such as excavation/drilling and connection to main earth grid.

Treated earth pits shall be treated with salt and charcoal. Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

16.4 Earthing Conductors

Earthing conductors shall have the following minimum sizes:

Transformers, LT Panel and standby DG Set	50 x 6 mm flat GI
Interconnection to building comprising the Works and to the Main Earth grid	50 x 6 mm flat MS
Interconnection to PCC/MCC/PMCC	50 x 6 mm flat GI
Power factor correction capacitor panel	25 x 3 mm flat GI
Local push buttons station	14 SWG GI wire 4 SWG GI wire / Equivalent copper flexible wire 12 SWG GI wire/Equivalent copper flexible wire
Outdoor Street lighting	8 SWG GI wire
Ladder rack and cable tray at suitable points	25 x 3 mm flat GI
Hand rails and metallic structures, crane rails, air handling ductwork etc.	25 x 3 mm flat GI
LV Motors	
Up to 10 kW	8 SWG GI wire
10 to 20 kW	4 SWG GI wire
Above 20 kW	25 x 3 mm flat GI

Notes:

1. Definitions: GI is galvanized Iron; MS is mild steel.
2. Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor.
3. Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.
4. Location of earth electrode/ earth conductor shall be decided at site to suit actual location of trays, trenched electrical equipment's and pipe sleeves.
5. All instruments and PLC/SCADA shall be earthed by copper wires/strip connected to independent copper earthing pit as per manufacturer recommendation.

17. CCTV SYSTEM

17.1 General

Proposed CCTV system shall be an open standard based integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance.

System shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on work stations/monitors at Central Control Room/local control rooms and simultaneously record all the cameras after compression using MPEG 4 or better standard. Joystick or Mouse-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.

System shall have combination of Digital CCD Colour video Cameras with individual IP address, analog CCD Colour Video Cameras with Fixed or P/T/Z Lens, encoders/decoders, Network Video recorders (NVR/CAMERA SERVER), Network attached storage (NAS) / Raid backup device for recording, Application software, Colour Video Monitors, Keyboards with Joystick controllers / Mouse-Keyboard, software based Video Matrix Switcher, work station for System Administration / Management / Maintenance etc.

The NVR / CAMERA SERVER can be embedded type or server based. However the NVR / CAMERA SERVER software shall run on common off the shelf available servers (Camera server & Database server). Each NVR / Camera Server shall be able to handle 12 or more cameras.

Network Video Recorder shall offer both video stream management and video stream storage management. Recording frame rate & resolution in respect of individual channel shall be programmable.

System should ensure that once recorded, the video cannot be altered, ensuring the audit trail is intact for evidential purposes. System shall provide sufficient storage of all the camera recordings for a period of 30 days or more @ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras (extended capacity of cameras i.e. present capacity + 25%).

System shall use a combination of IP enabled cameras & analog CCD cameras with external encoder. The video shall be compressed using MPEG-4 or better standard and streamed over the IP network.

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Encoders shall digitize analog video, compress the digital video using various compression algorithms for outdoor installations, shall be suitable to work from (-) 10° C to (+) 50° C with RH up to 90% non-condensing.

17.2 System requirements

Camera with external encoder or IP Camera shall be used for image capture. Indoor cameras shall be either with fixed focal length lens or with Pan/Tilt & Zoom lens as per site requirement. All outdoor Cameras shall be Day/Night cameras.

Housing of cameras meant for indoor use shall be of IP 42 rating whereas outdoor camera housing shall be of IP 66 or better rating. These must be integrated by the camera manufacturer. System must provide built-in facility of water marking or Digital certificate to ensure tamper proof recording so that these can be used as evidence at a later date, if so desired. The recording shall support audit trail feature.

All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with user ID & Password.

Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system. Facility of Camera recording in CIF, 2CIF, 4 CIF as well as in any combination i.e. any camera can be recorded in any quality. Selective or Group of cameras must be available in the system.

System shall have facility of additional camera installation beyond the originally planned capacity. In order to optimize the memory, while recording, video shall be compressed using MPEG-4 or better standard and streamed over the IP network. Once on the network, video can be viewed on a Control room work station or on analogue monitor using a hardware decoder (MPEG-4/compatible standard receiver) and shall be recorded on NVR/CAMERA SERVER and shall be backed up on NAS/RAID backup device.

System shall be triplex i.e. it should provide facility of viewing, recording & replay simultaneously. The offered system shall have facility to export the desired portion of clipping (from a desired date/time to another desired date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.

PTZ Cameras shall have 64 or more pre-defined positions, to be selected through suitable input alarm. System shall have provision of WAN connectivity for remote monitoring.

17.3 System design

Each camera should be connected to a Hardware Encoder, through cable, which shall support minimum dual streams. Alternatively, the camera shall be IP based, UTP ready. The encoders should be capable of producing streams @ 25 fps for each camera for viewing on LAN and on monitors and also recording into the NVR/CAMERA SERVER/Camera servers and NAS box/Raid backup device @ 25 fps or lower frame rate, user selectable as per requirement, for each individual camera.

Encoders shall be Power Over Ethernet (POE) compliant and connected to Layer 2 or Layer 3 switch as per system design using UTP CAT 6 Cable or fiber optic cable and the required connectors as per standards. For monitoring purposes, Video monitors/Plasma monitors/Video wall shall be set up with suitable mounting arrangements, as per user requirements. Facility for viewing and controlling all the cameras at various other locations, as required, shall be provided.

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Monitoring at Local control rooms may be restricted to operation of certain cameras only & system administrator should be able to configure the system, accordingly. There shall be a Control System with Video Control Software to manage all the video surveillance devices.

17.4 Video Surveillance Application Software

The software shall operate on open architecture for integration with perimeter safety, access control, PA and fire / safety systems based on open standards. Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoders, video decoders, PTZ controller, NVR, NAS boxes/Raid backup device etc. The software should have inbuilt facility to store configuration of encoders / decoders and cameras. The software should support flexible 1/2/4 Windows split screen display mode or scroll mode on the PC monitor or on preview monitor as per site requirement. The software should be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, selection of presets, Video tour selection etc.

The software should have user access authority configurable on per device or per device group basis. The user shall have the facility to request the access of any camera and can control the camera for a reservation period. Control of camera is released after the reservation period.

The system shall provide User activity log (audit trail) with user ID, time stamp, and action performed etc. The administrator should be able to add, edit & delete users with rights. It shall be possible to view ability / rights of each user or the cameras which can be viewed & controlled as per the permission assigned by the administrator.

It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.

17.5 Retrieval

The CCTV application should allow retrieval of data instantaneously or any date / time interval chosen through search functionality of the application software. In case data is older than 30 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like CD/DVD/ Blu ray Recorders or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system which can be audited at a later date.

17.6 Detailed Technical Specifications

i. Colour video Dome Camera with PTZ

Image Device	Inter line transfer 1/4" or better format CCD sensor
Focal length	4mm to 72 mm or better
Optical zoom (For Indoor Camera)	18X or better
Optical zoom (For Outdoor Camera)	26X or better

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Number of Pixels	720X576
Scanning System	PAL
Resolution	480 TVL or better
Illumination (For Indoor camera)	1.0 Lux (Color),0.1Lux(B/W) or better
Illumination (For Outdoor camera)	1.0 Lux(Color),0.05Lux(B/W) or better
Pan Travel	360 ⁰ Continuous
Tilt Travel	0-90 ⁰
Manual Tilt Speed	0.5°/SEC to 90°/SEC
Manual pan speed	0.5°/SECto90°/SEC
Preset Tilt speed	0.5°/SEC to90°/SEC
Preset Pan speed	0.5°/SEC to 300°/SEC
Preset positions	Min.64
Iris Control	Auto
Focus	Auto
Back Light compensation	Required with black masking or other suitable technology
White balance	Auto
Electronic shutter	Auto
S/N ratio	>=48 dB
Power supply	As per OEM's design, however generally AC 230V @50Hz/12Vor 24 VAC Rectifier and SMPS if DC supply

ii. Bullet Camera

Signal System	NTSC/PAL	
Image Sensor	1/3" Sony Super HAD	
Scanning System	2:1 Interlace	
Horizontal Resolution	600 TV Lines	
Synchronization	Internal	
Luminance S/N	More than 50dB (AGC	
Min. Illumination	0 Lux (IR LED On)	
Gamma	Adjustable / User	
Video Output Level	1.0 Vp-p Composite	
Day and night	True Day and Night	
IR LED	850nm, 20ea, Up to 30m	
IR LED Operation	On: 1Lux, Off: 3Lux	
IP Rating	IP66 (Water Repellent)	
OSD Display	Built-in	
	Sense-Up	Auto Adjustable
	3DDNR	0~100 Level Adjustable
	D-WDR	Off/Indoor/Outdoor
	BLC	Off/BLC/HSBLC
	Image	Freeze / Mirror /D-zoom / Sharpness /NEG Image
	Gain Control	Off/Low/Middle/High

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	White Balance	ATW/ PUSH/PUSH-LOCK/MANUAL/INDOOR
	Motion	Zone 4ea (Mask On/
	Privacy Masking	Zone 8ea (Mask On/
Function	Language	Standard :English
Operating Temperature		-10°C~50°C (14°F~122°F)
Storage Temperature		-20°C~60°C (-4°F~140°F)
Power Supply		Dual: DC12V±10% /AC 24V±10%

iii. Fixed Colour Dome Camera Varifocal

Image Device	1/3" or 1/4" CCD Sensor
Number of Pixels Minimum	720x576
Scanning System	PAL
Resolution	480 TV Lines or better
Min Illumination	1 Lux at F1.2
S/N Ratio	>=48 dB
Electronic Shutter	AUTO
Lens	Built-in Varifocal lens. Auto Iris, lens f=4–9mm. (approx.)
Back light compensation	Required
Power supply	As per OEM's design

iv. MPEG4 Encoder (Hardware Based)

The encoder shall be built on embedded processor and real time operating system. The Encoder should convert Analog Composite/S-Video input into good quality digital stream on real time basis and shall be able to transmit as Unicast /Multicast IP packet with low latency (less than 200 msec.) for live viewing as well as for recording.

The video resolution should be configurable at either of 4 CIF, 2 CIF, CIF @ 25 fps or at lower frame rate per camera, user selectable.

The encoder should generate MPEG4 video stream Compliant with ISO/IEC 14496 standard. The encoder should be interchangeable with any standard encoder of any other make, which generates MPEG4 video stream Compliant with ISO/IEC 14496 standard.

Encoder should have the following specifications or should match with the requirement.

Format	PAL color, B/W, composite, 25fps, 2:1 interlaced
Resolution (HxV pixels)	4CIF 704x576, 2CIF, CIF, QCIF
Frame Rate	25fps (PAL) and lower
Encoding	MPEG-4 Compliant with ISO/IEC 14496 Standard
Video Parameters	Brightness, contrast, hue, sharpness and sizings electable
Video Latency	Less than 200 msec.
Connectors	BNC for Composite Video for input, suitable connectors for Power, Alarm in, and Alarm out, RJ-45 for Ethernet 10/100 Base-T output.
IP Address	Static IP Address or as per System requirement.
MPEG4 standard	Compliant with ISO/IEC 14496

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IP Packets	Unicast and Multicast
POE	Compliant
Power supply	As per OEM's design

v. Network Attached Storage

NAS box/RAID backup device shall be used to record video streams based on the configuration assigned by administrator. Work stations & Servers within the LAN should be able to access the recorded video streams. The NAS/RAID backup device should support simultaneous play back and recording at full duplex operation.

It shall provide a high quality recording storage and play back of images. It should support integration with LAN to provide Centralized Management and shall operate on Windows / Linux OS. Support of user management for security level control and authentication required.

The minimum capacity of storage device shall not be less than 2TB.

vi. Camera Housing & mount

The camera mount should be:

- i. Of the same make as that of camera and suitable for the model number offered as specified by the manufacturer and should be an integrated unit.
- ii. Should be compact and indoor / outdoor type as required.
- iii. Should support the weight of camera and accessories such as housing, pan & tilt head in any vertical or horizontal position etc.

vii. Speed dome controller/PTZ controller

Speed Dome Controller should have variable speed joystick, LCD display for Programming and it should be able to control the speed dome for PAN / TILT / Zoom.

viii. Cables

Sr. No.	Connectivity	Cable Type
1	Camera to Video Encoder	CoaxialRG6/U/CAT6/Fibre Optic
2	Video Encoder to Switch in control room	UTPCAT6/Fibre Optic
3	Switch to Video Wall Switches	UTPCAT6/Fibre Optic
4	From switches to NAS Box	Fibre Optic
5	Hardware Decoder to monitor	Composite signal cable