SECTION- B 2.9

MOTOR STARTERS

2.9.1 PREMABLE

A. This section of specification defines the technical requirements for Motor starters up to 1000V as specified in accordance with the requirements of the Contract Documents and codes.

B. Scope of work includes Design, Manufacture, Assembly, Inspection and testing at Manufacturer's Works, Delivery to Site, Installation and Commissioning of the Motor starters, complete as specified in the schedule of requirement meeting the intents of the Tender. This specification shall be used in conjunction with all drawings, Schedule of requirement and BOQ attached. Scope of work includes erection, testing and commissioning services with necessary termination cabling / bus work required for satisfactory operation of the whole system

C. Starters are described as follows
   1. DOL STARTER
   2. STAR DELTA STARTER
   3. SOFT STARTER
   4. VARIABLE FREQUENCY DRIVES

D. Harmonic Analysis Study

   1. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFD input filtering to limit TDD and THD (V) at each VFD to specified levels.

   2. Prepare a harmonic analysis study and report complying with IEEE 399 and these contract documents.

2.9.2 SUMMARY

A. The equipment shall comply with the technical specification and guaranteed technical particulars specified herein. Any deviations to the specification shall be indicated clearly clause by clause

B. The complete system shall comply to requirements.

C. Codes and Standards: The Motor Starter shall be designed, manufactured and tested in accordance with the latest applicable sections of the IEC/BS/IS codes. Since IS Standards are originated from IEC standards, technical requirements listed in the latest IEC standards supersedes IS standards requirements which do not cover them.

IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
IEC 60073	Coding principles for indicator lights and push buttons.
IEC 60189	PVC insulated cables for switchgear and control wiring.
IEC 60255	Electrical relays.
IEC 60258	Direct acting recording electrical measuring instruments and their accessories.
IEC 60269	Low-voltage fuses.
IEC 60417 DB	Graphical symbols for use on equipment.
IEC 60439	Low voltage switchgear and control gear assemblies.
IEC 60445	Basic and safety principles for man-machine interface marking and identification. Identification of equipment terminals and of termination's of certain designated conductors. Including general rules for an alphanumeric system.
IEC 62052	Electricity metering equipment (AC)
IEC 60529	Degrees of protection provided by enclosures. (IP Code)
IEC 60715	Dimensions of low voltage switchgear and control gear. Standardised mounting on rails for mechanical support of electrical devices in switchgear and control gear installations.
IEC60947	Low Voltage switchgear and control gear
IEC TR 61641	Enclosed LV Switchgear and Control gear assemblies – guide for testing under conditions of arcing due to internal fault.
IEC 60439-1	Low Voltage Switchboard
IEC 60831	Capacitor switching contactors
IS/IEC 60947 : PART 3	Low voltage switchgear and control gear : Part 3 Switches, Disconnector, switch-Disconnector and fuse combination units.

IS/IEC 60947 : Part 4 : Sec 1	Low-Voltage Switchgear and Control gear - Part 4 : Contractors and Motor-Starters - Section 1 : Electromechanical Contactors and Motors-Starters
IS/IEC 60947 : PART 4 : Sec 3	Low voltage switchgear and control gear : Part 4 AC semiconductor controllers and contactors for non-motor loads
IS/IEC 60947 : Part 5 : Sec 1	Low-Voltage Switchgear and Control gear - Part 5 : Control Circuit Devices and Switching Elements - Section 1 : Electromechanical Control Circuit Devices
IS/IEC 60947 : Part 4 : Sec 2	Low-Voltage Switchgear and Control gear : Part 4 - Contractors and Motor-Starters Section 2 ac Semiconductor Motor Controllers and Starters

IS 5082	Material for data for aluminium bus bars
IS 13703	Low voltage fuses.
IS 1248	Electrical indicating instruments.
IS 13010	AC Watt hour Meters, Class 0.5, 1 and 2
IS 3231	Electrical relays for power system protection.
IS 13947 : Part 5 : Sec 2	Control Circuit Devices and Switching Elements - Section 2 : Proximity Switches
IS 694	PVC insulated cables for working voltages upto and including 1100V.
IS 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS 5578	Guide for marking of insulated conductors.
IS 3618	Phosphate treatment of Iron and steel for protection against corrosion.
IS 6005	Code of practice of phosphating of Iron and steel.
IS 5	Colours for ready mixed paints and enamels.
IS/IEC 60947 : Part 1	Degree of protection provided by enclosures for switchgear and Control.

2.9.3 SUBMITTALS

A. Product Data: For each type of motor starter and related equipment, include the following: Rated capacities, operating characteristics, furnished specialties, and accessories for individual element. Time-current characteristic curves and discrimination tables for all over current protective devices, including devices & weight of the sections.

B. Danger/Warning labels shall have white lettering on a red background and shall be in English, Hindi and Marathi. All other labels shall have black lettering on a white background. All labels shall be fixed by screws or rivets.

C. Shop Drawings: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:

- Tabulation of installed devices with features and ratings.
- Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
- Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
- Floor plan drawing showing locations for anchor bolts [and levelling channels].
- Current ratings of buses.
- Short-time and short-circuit ratings of switchgear assembly.
- Nameplate legends.
- Mimic-bus diagram.
- Wiring Diagrams: For each type of switchgear and related equipment, include the following:
    1. Power, signal, and control wiring.
    2. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
    3. Schematic control diagrams.
    4. Diagrams showing connections of component devices and equipment.
    5. Schematic diagrams showing connections to remote devices.

D. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
   a. Design Calculations: Calculate requirements for selecting seismic restraints.
   b. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

E. Documents shall comprise but not limited to the following :

   a. Indicates that the document to be submitted as per the Lodha approved material submission schedule.
   b. Indicates that the document to be submitted after successful testing and commissioning of the integrated system before handing over of the system.

Sr. No.	Engineering Data	Reqd. With Bid	Required after Purchase Order			
			For approval		As built	
			Qty	Schedule Days	Qty	Schedule Days
1	Outline dimension drawing	yes	4	A	6	B
2	Heat dissipation calculations	yes	4	A	6	B
3	Cross sections with part description & Foundation dwg.	yes	4	A	6	B
4	Completed Data Sheets	yes				
5	Bill of Materials for scope of Supply	yes	4	A	6	B
6	Installation Drawings, Operation / Maintenance Manual				4	With dispatch
7	Priced Spare List for 2 years service	yes				
8	Terminal point schedule / drawing		4	A	6	B
9	Control Schematic Diagram	yes	4	A	6	B
10	Type test certificate for short circuit breaking current of circuit breaker				6	At the time of inspection
11	Type test certificate for short circuit withstand.				6	At the time of inspection
12	Inspection Test Reports				6	At the time of inspection
14	Test Certificates for bought out items				6	
14	Quality Test Plan				6	
15	Switchgear Discrimination analysis and switchgear discrimination tables	yes	4	A	6	B

F. Manufacturer Seismic Qualification Certification: Submit certification that Low voltage Switchgear, accessories, and components will withstand seismic forces. " Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify centre of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2.9.4 QUALITY ASSURANCE

1. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Country, State, and Municipal authorities having jurisdiction & applicable Standards.
2. Standards: The Low voltage Switchgear and Accessories shall confirm to the requirement of latest revision of all relevant Indian Standards and also IEC Standards.
3. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
4. Electrical Components, Devices, and Accessories: Listed and labeled as per IS 732 1989 (reaffirmed 2005), by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

2.9.5 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, those listed in the relevant MEP Specifications under Section G.

2.9.6 CONSTRUCTION

2.9.6.1 MOTOR STARTERS

A. General requirement

1. ENCLOSURE/ CONTROL CABINET

Motor starters shall be in accordance with respective codes as specified above. The starters shall be totally enclosed, metal clad, dust and vermin proof construction. The starters shall be of continuous rating and shall be of automatic type. All starters shall be suitable for 415 volts, 3 phases, 50 HZ, A.C. supply.

The enclosure shall be wall mounted/ free standing type with an IP-55 enclosure of suitable rating (or specified optional cabinet).

Control cabinet shall include the following, but not be limited to:

a. Motor protection
b. Dry run protection – Float switch / Inlet pressure monitoring device for suction lift condition
c. Earthing provision
d. Ethernet connectivity (Web based control)
e. Potential free contacts to hook up the system tom BMS if required
f. 320 X 240 pixels VGA display with adjustable backlight
g. Programmable controller with Keypad and display screen mounted through the outer door as per plumbing/HVAC/Fire fighting Pump requirement.
h. Pump Fault Lights – A Red light for fault indications
i. Visual Alarm
j. Pump Elapsed Time Meters
k. Manual Operation
l. Low water
m. Power on
n. Pump on
o. Pump Stop

p. Pump Trip

q. Off / Auto / Duty pump selector

r. Water level indication with high/low alarm

i. The high level alarm panel shall include an alarm horn, warning light, silencing switch and a dry contact for remote alarm annunciation in guard room ground floor.

ii. Required

s. Provide 4 mercury float type level switches with 10 m of water proof cable for duplex units for following control logic

i. Control Action Type of Signal

ii. Pump 1 & 2 on High Level

iii. Pump 1 on Medium level

iv. Pumps off Low Level

v. High Level Alarm Overflow

t. The supporting system for packaged pumping system shall be mounted on a Hot Dipped Galvanized MS or SS fabricated skid. The control cabinet shall be mounted in one of the following ways depending on the size of the cabinet.

i. On a Hot Dipped GI or MS fabricated control cabinet stand attached to the system skid

ii. On a Hot Dipped GI or MS fabricated skid, separate from the main system skid

iii. Floor mounted control cabinet with plinth.

B. TECHNICAL REQUIREMENT

1. The type of starter to be used shall be as follows (to be read in conjunction with MEP equipment schedules):

a. Type of Motor Staring Method

i. Constant Speed motors up to and including 7.5kW: Automatic Direct on Line starters.

ii. Constant Speed motors of above 7.5kW : Automatic Star-Delta Starters

iii. Two Speed Motors Automatic : DOL/Star-Delta Starters

iv. All Fire fighting Pumps : Soft Start / DOL Start (as noted in Contract Documents)

v. Variable frequency drive (VFDs)

2. The starting current of the motors shall be limited by using the above mentioned starters, as required.

3. Where individual starters and controls are grouped together, the Contractor shall provide a panel for mounting this equipment.

4. All motor starters will be provided with Type 2 Co-ordination such that under short circuit conditions, the contactor or starter shall cause no danger to persons or installation and shall be suitable for further use. The risk of contact welding is recognized, in which case the manufacture shall indicate the measures to be taken in regards to equipment maintenance.

5. Starter feeders shall be equipped with but not limited to:

a. Incomer MPCB/MCCB/MCB with door interlocked rotary handle. (Lockable in the off position).
b. Contactors for direct on-line starting or star-delta starting as noted in the contract documentation.
c. Starters shall be provided with sufficient extra N/O contacts for interlocks, indicating lamps, etc.
d. Thermal overload relay with built in single phasing prevention feature.
e. Hand-Off-Auto control switch.
f. Common duty selector switch.
g. Thermister relay.
h. RUN/TRIP lamps.

i. Auto changeover arrangement.

2.9.6.2 DIRECT ON LINE TYPE STARTER

1. Starter shall have MPCB/MCCB/MCB incomer for short circuit & over current protection.
2. Provide starters incorporating over current protection & short circuit protection for motors starters.
3. Contactors shall have the number of poles as required for appropriate duty. The making capacity of the contactors shall be as per AC23 of ISS.
4. Unless other specified, all starters shall have integral start/stop push buttons. Start push buttons shall be coloured green and shall be shrouded to prevent inadvertent operation. Stop push buttons shall have mushroom heads and shall be coloured red. All push buttons operated contractors shall be provided with a hold-on/running contact.
5. All remote control circuit connected to be starters shall operate at 230 volts or lower voltage.
6. Motor starters shall be provided with thermal overload relay with adjustable settings, one each phase for three phase motors. Single phasing preventers shall be provided for all three phase motors.
7. Terminal block with integral insulating barriers shall be provided for each starter.
8. All starters shall be provided with a schematic diagram on a durable material fixed permanently within each lid or cover.
9. Starters shall be provided with sufficient extra N/O contacts for interlocks, indicating lamps, etc.

2.9.6.3 STAR DELTA STARTER

1. Starter shall have MPCB/MCCB/MCB incomer for short circuit & over current protection.
2. Provide starters incorporating over current & short circuit protection for motors starters.
3. Contactors shall have the number of poles as required for appropriate duty. The making capacity of the contactors shall be as per AC23 of ISS.
4. Unless other specified, all starters shall have integral start/stop push buttons. Start push buttons shall be coloured green and shall be shrouded to prevent inadvertent operation. Stop push buttons shall have mushroom heads and shall be coloured red. All push buttons operated contractors shall be provided with a hold-on/running contact.
5. All remote control circuit connected to be starters shall operate at 230 volts or lower voltage.
6. Motor starters shall be provided with thermal overload relay with adjustable settings, one each phase for three phase motors. Single phasing preventers shall be provided for all three phase motors.
7. Terminal block with integral insulating barriers shall be provided for each starter.
8. All starters shall be provided with a schematic diagram on a durable material fixed permanently within each lid or cover.
9. Automatic Star/Delta starters shall be provided with adjustable timers.
10. Starters for wound rotor motors shall be rotor resistance type and shall be oil/air immersed, metal clad construction with combination of drum type rotor resistance starter and starter switch. Rotor starter shall be used for starting only. The starter switch shall be of heavy duty, with trip free mechanism. The tripping mechanism shall not reset until the starter handle is in "OFF' position.
11. For Star//Delta starters incorporate adjustable time delay contactor relays, to control star delta changeover, ensuring electrical endurance compatible with starter contactors. Ensure starting sequence activated on voltage restoration.

2.9.6.4 SOFT STARTERS

1. Provide soft-start starters as noted in Tender Documentation.
2. Soft start starters shall be provided for the specified service. Soft start starters shall consist of a main disconnect switch, a mechanical contactor, a six-SCR full wave bridge solid state reduced voltage starter, a thermal overload relay factory assembled in a single enclosure, with ratings, features and accessories as specified below.

3. The soft start shall be capable of controlling the starting inrush of a NEMA design B motor, and to reduce water hammer effects of the pumps when the motor is stopped.
4. Ratings and features:
    a. Starter voltage as noted on electrical SLD.
    b. Enclosure type, NEMA 1 ventilated.
    c. Main AC line fused disconnects or circuit breaker mounted and wired, with a door interlock mechanism and padlocking means.
    d. Starter shall include a full NEMA style; HP sized and rated series contactor, including contacts and coils, ahead of the solid state electronics. Contactor shall open on normal stop command, and if a shorted SCR is detected.
    e. Starter shall be rated for a minimum of 350 present current for 30 seconds.
    f. Starter shall include adjustable thermal overload protection.
    g. Starter shall include maintained contact H-O-A selector switch and red running pilot light.
    h. Starter shall include an integral 230V control circuit transformer with primary and secondary fusing.
    i. Starter shall be rated for full current operation at 40 degrees C ambient temperature..
    j. In addition to the interlock & switches specified above each soft start starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.
5. Protective features and adjustments:
    a. SCR's shall be rated 1600 PIV minimum.
    b. Instantaneous over current trip shall be included if current exceeds 900 percent FLA.
    c. Metal Oxide Varistor (MOV) suppressors shall be provided.
    d. Heat sink over temperature switch shall be provided.
    e. Starter shall include shorted SCR detection and lockout.
    f. Starter shall not start if a phase loss condition is present.
    g. Diagnostics shall include LED indicators for:
        1. 3 phase power present
        2. Shorted SCR detected
        3. Motor overload
        4. Instantaneous over current
        5. Starter ready
        6. Starter on
        7. Power supply failure
    h. A fault relay shall be included to trip the series contactor in the event of motor thermal overload, instantaneous overcurrent, of presence of a shorted SCR.
    i. Adjustments shall include ramp time, current limit, jog voltage, jog time, and deceleration time.
6. Operational Features:
    a. On starting, the starter shall be capable of applying an adjustable "jog" voltage to the motor for an adjustable time to magnetize the motor, and then automatically switch to a controlled current ramp mode to accelerate the load.
    b. On stopping, the starter shall include an "anti-water hammer" circuit which is capable of accepting a 0-10V DC signal proportional to flow from the building automation system and controlling the voltage to the motor to obtain a smooth reduction in flow without excessive pipe

movement or water hammer. As a backup, a linear voltage ramp deceleration mode shall be available.

7. Field Start-up and Service:
   a. Soft starter supplier shall provide authorized factory trained service personnel to do on-site start-up and adjustment for each soft start starter.

2.9.6.5 VARIABLE FREQUENCY DRIVE

A. VFD DESCRIPTION:

1. The variable frequency drive enclosure shall include dry-contact fault-output relay contacts along with analog and digital inputs. The motor shall detect/protect itself against under voltage, over voltage, excessive temperature, and set-point signal fault
2. Variable-frequency drive (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and over current and overload protection; as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   a. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
3. Unit Operating Requirements:
   a. Input AC Voltage Tolerance: Plus ± 6percent of VFD input voltage rating.
   b. Input AC Voltage Unbalance: Not exceeding 3 percent.
   c. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
   d. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
   e. Minimum Short-Circuit Current (Withstand) Rating: 25 kA.
   f. Vibration Withstand: Comply with IEC 60068-2-6.
   g. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
   h. Starting Torque: Minimum 100 percent of rated torque from 3 to 50 Hz.
   i. Speed Regulation: Plus or minus 5 percent.
   j. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
   k. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
4. Internal Adjustability Capabilities:
   a. Minimum Speed: 5 to 25 percent of maximum rpm.
   b. Maximum Speed: 80 to 100 percent of maximum rpm.
   c. Acceleration: 0.1 to 999.9 seconds.
   d. Deceleration: 0.1 to 999.9 seconds.
   e. Current Limit: 30 to minimum of 150 percent of maximum rating.
5. Self-Protection and Reliability Features:
   a. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   b. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   c. Under- and overvoltage trips.
   d. Inverter over current trips.

e. VFD and Motor Overload / Over temperature Protection: Microprocessor-based thermal protection system for monitoring VFD's and motor thermal characteristics, and for providing VFD over temperature and motor overload alarm and trip; settings selectable via the keypad.

f. Critical frequency rejection, with three selectable, adjustable dead bands.

g. Instantaneous line-to-line and line-to-ground over current trips.

h. Loss-of-phase protection.

i. Reverse-phase protection.

j. Short-circuit protection.

k. Motor over temperature fault.

6. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

7. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Auto speed Search" feature is available and engaged.

8. Bidirectional Auto speed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

9. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

10. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

11. Integral Input Disconnecting Means and OCPD: NEMA KS 1, fusible switch with pad lockable, door-mounted handle mechanism.

a. Disconnect Rating: Not less than 115 percent of VFD input current rating.

b. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.

d. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

e. NC or NO alarm contact that operates only when circuit breaker has tripped.

C. CONTROLS AND INDICATION

1. Status Lights: Door-mounted LED indicators displaying the following conditions:

a. Power on.

b. Run.

c. Overvoltage.

d. Line fault.

e. Overcurrent.

f. External fault.

2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

c. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

3. Historical Logging Information and Displays:
   a. Real-time clock with current time and date.
   b. Running log of total power versus time.
   c. Total run time.
   d. Fault log, maintaining last four faults with time and date stamp for each.
4. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
   a. Output frequency (Hz).
   b. Motor speed (rpm).
   c. Motor status (running, stop, fault).
   d. Motor current (amperes).
   e. Motor torque (percent).
   f. Fault or alarming status (code).
   g. PID feedback signal (percent).
   h. DC-link voltage (V dc).
   i. Set point frequency (Hz).
   j. Motor output voltage (V ac).
5. Control Signal Interfaces:
   a. Electric Input Signal Interface:
      1. A minimum of two programmable analog inputs: 0- to 10-V dc 3- to 20-mA dc.
      2. A minimum of six multifunction programmable digital inputs.
   b. Pneumatic Input Signal Interface: 3 to 15 psig.
   c. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
   d. 0- to 10-V dc.
   e. 3- to 20-mA dc.
   f. Potentiometer using up/down digital inputs.
   g. Fixed frequencies using digital inputs.
   h. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc 3- to 20-mA dc), which can be configured for any of the following:
      1. Output frequency (Hz).
      2. Output current (load).
      3. DC-link voltage (V dc).
   i. Motor torque (percent).
   j. Motor speed (rpm).
   k. Set point frequency (Hz).
   l. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

1. Motor running.
2. Set point speed reached.
3. Fault and warning indication (overtemperature or overcurrent).
4. PID high- or low-speed limits reached.

m. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

n. BMS Interface: Factory-installed hardware and software to enable the BMS to monitor, control, and display VFD status and alarms and energy usage. Allows VFD to be used with an external system within a multidrop LAN configuration; settings retained within VFD's non-volatile memory.

o. Network Communications Ports: Ethernet and RS-232/485.

D. LINE CONDITIONING AND FILTERING

a) Input Line Conditioning: Based on the Contractors harmonic analysis study and report, provide input filtering, as required, to limit THD(i)at input terminals of all VFDs to less than 5 percent and THD(V) to 3 percent.

E. BYPASS SYSTEMS

a) Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

b) Bypass Mode: Manual operation only; requires local operator selection at VFD. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.

c) Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

d) Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1 Bypass Contactor: Load-break, IEC-rated contactor.

2 Output Isolating Contactor: Non-load-break, IEC-rated contactor.

3 Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

e) Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

1 Bypass Contactor: Load-break, IEC-rated contactor.

2 Input and Output Isolating Contactors: Non-load-break, IEC-rated contactors.

3 Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

2.9.6.6 EMERGENCY START/ STOP PUSH BUTTON

A. Shall be provided with 2No positive action N/C contacts.
B. Shall be provide with 1 No N/O contacts
C. Housing material shall be Plastic
D. Enclosure rating shall be IP 65
E. Connection type (contacts) shall be Screw connection
F. Mounting diameter shall be a minimum of 22 mm
G. Mechanical life shall be a minimum of 50.000 switching cycles
H. Ambient operating temperature shall be from–40 °C to +70 °C
I. Protection class II
J. Usage category shall comply with IEC
K. Rated insulation voltage Ui 600 V
L. Minimum switching voltage 5 V DC
M. Minimum switching current 1 mA
N. Connection type (contacts) Screw connection
O. Maximum connection cable cross-section 2.5 mm²
P. LED indicator lamps shall be provided
Q. Emergency Start / Stop button to be coloured 'RED'
R. Emergency push buttons to be provide to the following mechanical equipment (under the relevant services contractors scope
    1 Pumps
    2 AHUs
    3 Fans

2.9.7 EXECUTION

2.9.7.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive Motor starter, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.
B. Examine starter before installation. Reject if they are wet, moisture damaged, or mold damaged.
C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before installation.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

2.9.7.2 INSTALLATION

A. Install motor starters as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of applicable standards or codes approved.
B. Install motor starters only after the room has been fully completed, including all painting and made dust tight and vacuum cleaner.
C. Installation to be certified by manufacturer/authorized representative.
D. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with the approved Shop and Construction Drawings and equipment manufacturers' drawings and holes for fixing bolts and provisions for passage of cables etc. are provided as required.

E. Alternatively, starter can be anchored to steel-channel sills 100 mm high (min and as necessary), arranged and sized according to manufacturer's written instructions. Attach by tack welding or bolting. Level and grout sills flush with motor control center mounting surface

F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from main distribution board units and components.

G. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

H. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts. Installation to be inspected and certified as fit for “energization” by manufacturer/authorized representative.

I. Supports and Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.

J. Relays: Set in accordance with manufacturer’s instructions and in accordance with an approved scheme.

K. Make Good, damage painted surfaces, clean and apply rust-inhibiting prime coat and 2 finishing coats of approved enamel upon delivery of equipment to site, or as required by the Engineer.

L. Operating Instructions: Frame and mount the printed basic operating instructions for main distribution boards, including control and key interlocking sequences and emergency procedures. Fabricate frame of metal and cover instructions with clear acrylic plastic. Mount in front of main distribution boards.

M. Install clear copy of certified and stamped “As-Built” drawings inside the starter.

N. Install panel key on stainless steel chain fixed securely alongside board.

O. An approved type 1.20m wide non-slip rubber floor mat in accordance with IEC 61111 and rated to 1.0kV shall be fitted along the full length of each starter panel supplied. This material shall suitable for heavy duty electrical safety matting and shall be fully tested and certified for electrical insulation properties to IEC 61111; 2009 and shall be continuously marked with 5kV Proof Test, 10kV Withstand Voltage and 1000V Working. Each matt to IEC 61111 Class 0 - 6mm Thick.

2.9.7.3 CONNECTIONS

A. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.

2.9.8 FIELD QUALITY CONTROL

A. Equipment: Inspect equipment upon delivery to Site and report any damage to the Engineer.

B. Motor starter: Inspect and check switchgear, starter for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.

C. Prior to energization of circuitry, check all accessible connections to manufacturer’s torque tightening specification.

D. Tests: After installation and before hand-over, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including, but not limited to, the following. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest. All testing to be witnessed/certified by manufacturer as acceptable results.

1. Insulation resistance tests for each motor starter, component, connecting supply and control circuit.
2. Continuity tests of each circuit.
3. Operational tests.

E. Test Procedure: Conform to the following:

1. Protective Device and Relay Settings: Verify that settings given on the Drawings are appropriate for final system configuration and parameters based on system study. Where discrepancies are found, recommend final settings for approval before making final adjustments.
2. Submit short circuit and coordinated relay settings with calculations based on IEC from the medium voltage incomer to the final load.
3. Load shedding program to be developed by identifying the nonessential loads for generator or turbine loading.

F. Main and Control Circuits: Using 1000 V megger (2000 Megohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.

G. Primary Injection Tests: Provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.

H. Instantaneous Trip Elements: Test by high current primary injection, using high-current primary injection test-sets and reports all readings.

I. Routine tests on site are to be carried out on every main distribution board in accordance with the Standard for FBAs assembled from standardized components outside the works of the manufacturer. Routine tests are also to be carried out on every FBA, delivered to site, if requested by the Engineer.

J. Manufacturer/authorized representative shall install and certify "equipment ready for energization"

K. All test record certificates shall be clear, having a distinctive test certificate number, signed and certified by authorized testing agency, contractor and Engineer.

L. Conduct site test with Oscilloscope after loading of the MDB to demonstrate that harmonic filters function properly as specified.

M. Inspections and Tests for Power Factor Correction Capacitors: Inspect and test component features, functions, operations, and protective devices according to manufacturer's instructions and International Electrical Testing Association.

N. Re-test: Correct deficiencies identified by tests and observations and retest until specified requirements are met

2.9.8.1 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

2.9.8.2 DEMONSTRATION

A. General: Manufacturer's factory-authorized service representative to train the Employer's personnel in the operation of the Unit.

A. Equipment: Check operation of each unit with Owner's personnel present and before Substantial Completion. Determine that operational systems and devices are functioning properly.

B. Instruction: Instruct the Employer's personnel in proper use, maintenance, adjustment, and repair of each system.

END OF SECTION-2.9