

|             |   |           |
|-------------|---|-----------|
| <b>35</b>   | <b>MEDIUM VOLTAGE SOFT STARTER (&gt;1000 V) .....</b> | <b>2</b>  |
| <b>35.1</b> | <b>GENERAL.....</b>                                   | <b>2</b>  |
| <b>35.2</b> | <b>SUBMITTALS .....</b>                               | <b>2</b>  |
| <b>35.3</b> | <b>STANDARDS.....</b>                                 | <b>4</b>  |
| <b>35.4</b> | <b>QUALITY ASSURANCE.....</b>                         | <b>4</b>  |
| <b>35.5</b> | <b>WARRANTY .....</b>                                 | <b>5</b>  |
| <b>35.6</b> | <b>PRODUCTS .....</b>                                 | <b>5</b>  |
| 35.6.1      | Components .....                                      | 5         |
| 35.6.2      | Design Requirements .....                             | 5         |
| 35.6.3      | Enclosure construction: .....                         | 6         |
| 35.6.4      | Control Module .....                                  | 8         |
| 35.6.5      | Configuration .....                                   | 10        |
| 35.6.6      | Operational Controls.....                             | 10        |
| 35.6.7      | Control Power Transformers (CPT) .....                | 11        |
| 35.6.8      | Input and Output Controls.....                        | 11        |
| 35.6.9      | Faults and Alarms.....                                | 12        |
| 35.6.10     | Emergency Stop Control.....                           | 12        |
| 35.6.11     | Metering .....  | 12        |
| <b>35.7</b> | <b>INSTALLATION .....</b>                             | <b>13</b> |
| 35.7.1      | Documentation .....                                   | 13        |
| 35.7.2      | Commissioning .....                                   | 13        |
| 35.7.3      | Training .....  | 14        |

ARAB ENGINEERING BUREAU

## 35 MEDIUM VOLTAGE SOFT STARTER (>1000 V)

### 35.1 GENERAL

- 1 This Specification defines the requirements for Medium Voltage Soft Starter for the operation of pump motors.
- 2 The Manufacturer shall prepare a complete compliance with the Specification. Any exception shall be included in the compliance statement with an explanation, clearly indicating the paragraph of the Specification to which the exception applies, and concisely stating the reasons.
- 3 Unless clearly identified as an exception, the Specification shall have precedence where there is conflict between Manufacturer descriptive information and the Specification.
- 4 The manufacturer shall have a proven operation for more than 10 years.
- 5 For voltages and frequencies, regulations and requirements of Kahramaa and relevant authorities should be taken into account.

### 35.2 SUBMITTALS

- 1 Submittals shall comply with Employer's Requirements. Include derating factors for 50°C ambient temperature.
- 2 Product Data and catalogues: The following information shall be submitted:
  - (a) Description of general construction,
  - (b) Bus ratings (volts, phase, bus bracing and capacity)
  - (c) Branch and main protective devices and their ratings (voltage, current, short circuit level, IP rating)
  - (d) Special features and apparatus (e.g., metering equipment and protective relays)
  - (e) Manufacturer's specifications and technical data including performance, construction and fabrication
  - (f) Basic description of all major components, control and protection features of Soft Starter
  - (g) Dimensions and estimated weights clearly stated in the description or via outline drawings
  - (h) Single-line diagram showing all major components within the system
  - (i) Recommended spare parts list
  - (j) Rate schedule for field service
  - (k) Terms of standard warranty
  - (l) Wiring diagrams. Complete internal wiring of sensing and control devices of the system to be provided.
  - (m) List any exceptions to the specification.

- (n) Complete information on heat gains to the surrounding space from machines and equipment.
- (o) Complete data sheets
- (p) Operating and Maintenance Manuals
- (q) Testing, cleaning and maintenance instructions
- (r) Personnel operating instructions
- (s) Maintenance Materials List
- (t) Parts List/Diagram.
- (u) Service Organization
- 3 Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, including specific requirements indicated.
- (a) Submit shop drawings on the following items:
- Electrical requirements for power supply wiring to units.
  - Ladder wiring diagrams for interlock and control wiring, clearly differentiating between
  - portions of wiring that are factory-installed and portions to be field-installed
  - Submit Shop Drawings for each complete system or assembly of shop-fabricated, field fabricated and manufactured components.
  - List of any hardware required to be provided by others in order to make the equipment run
  - Single Line diagram of the complete lineup
- 4 Test Reports:
- (a) Submit following Test Reports:
- Contactors, Isolators and breakers proposed
  - Meters and protection relays
  - Hot operation Test (50°C)
  - Current transformers and voltage transformers used
- (b) Submit following Test Reports:
- Short Circuit
  - Power frequency withstand Voltage (BIL)
- (c) Factory tests shall be carried out at the manufacturer's factory in accordance with IEC or UL standards and shall be witnessed. Submit the detailed factory test procedure proposed.

### 35.3 STANDARDS

The soft starter shall be designed and materials shall be furnished in accordance with the latest revisions of applicable sections of the following Codes and Standards.

IEC 62272-200 .....High Voltage controlgear and switchgear – part 200

High voltage controlgear and switchgear in metal enclosure for voltages over 1 kV up to and including 52 kV

IEC 62272-1 .....High Voltage switchgear and controlgear – part 1 : Common Specifications

IEC 60060-1 .....High Voltage Test Techniques – Part 1: General Definitions and Test Requirements

CISPR-11 .....Industrial, scientific and medical (ISM) radio-frequency equipment - electromagnetic disturbance characteristics - limits and methods of measurement

IEC 61000-4-4 .....Electromagnetic compatibility (EMC) - Part 4: testing and measurement techniques - section 4: electrical fast transient/burst immunity test. Basic EMB publication

IEC 61000-4-18 .....Electromagnetic compatibility (EMC) - Part 4-18: testing and measurement techniques - damped oscillatory wave immunity test

NBR IEC 60529 .....Protective rates for electric equipment enclosures (IP code)

NEMA ICS 6 .....Industrial Control and Systems Enclosures

UL 347 .....Medium Voltage AC Contactors, Controllers and Control Centers

UL 347B .....Medium Voltage Motor Controllers

IEC 146-1-1 .....Semiconductor Converters

IEC 529 .....Degrees of protection provided by enclosures (IP Code)

NFPA-70 .....National Fire Protection Agency (NFPA) –70 National Electric Code (NEC), latest adopted edition.

OSHA .....Standard No. 29 CFR 1910.147 – The standard for control of hazardous energy (Lockout/Tagout).

IEC 1000-4-2 .....Electrostatic immunity test; (IEC 61000-4-2 Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test)

IEC 1000-4-4 .....Fast transient immunity test; (IEC 61000-4-4 Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test)

IEC 1000-4-5 .....Surge immunity test; (IEC 61000-4-5 Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test)

UL 508C .....Power Conversion Equipment

UL 467 .....Safety Standard for Grounding Equipment

### 35.4 QUALITY ASSURANCE

- 1 The manufacturer shall have ISO 9001 certification.

- 2 The manufacturer shall provide start-up service, 24 hour/day emergency call service, repair work, maintenance and troubleshooting training of customer personnel.
- 3 Soft starter shall be UL listed/EC certified.

### **35.5 WARRANTY**

- 1 The drive shall be warranted by the manufacturer for a minimum of three years from the date of commissioning in PWA name.

### **35.6 PRODUCTS**

#### **35.6.1 Components**

- 1 Soft Starter shall consist of following major components:
  - (a) No-Load break disconnect switch with blade grounding bar
  - (b) MV Fuses – R rated appropriately rated for required overload & number of starts
  - (c) MV contactors – for line supply and for bypass connections
  - (d) Phase controlled thyristor power modules – one per phase
  - (e) CTs for motor current measurement
  - (f) Ground Fault CT
  - (g) Control Power Transformer to be able to derive control voltage from line supply
  - (h) MV control board with line side and motor side voltage measurement,
  - (i) LV control board for field I/O & communications
  - (j) Door mounted LCD keypad and indicator lights for operator interface
- 2 All components and materials shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.

#### **35.6.2 Design Requirements**

- 1 The motor starters will be constructed as part of floor standing motor control centers and installed in a separate air-conditioned electrical equipment room with front and rear access. Electrical service wiring from the soft starter to each motor will be provided by the Contractor. Manufacturer to provide lug connections to each motor.
- 2 Controls shall be coordinated to provide proper operation.
- 3 All motor starters and controllers shall be designed, manufactured and tested to meet or exceed the requirements of the latest published standard of IEC in addition to local authority requirements. Supplier to list the standard used.
- 4 Motor controllers shall accept nominal power of 3.3/6.6/11 kV AC ( $\pm 10\%$ ), 3-phase, 50 Hz ( $\pm 3\%$ )

- 5 The starters shall be manufactured in sections, assembled and fully tested in the factory and witnessed by the Engineer. Then they shall be dissembled, shipped to site, reassembled and tested again. The testing in the factory shall require the panel manufacturer's provision of motor test loads to demonstrate all the equipment.
- 6 The Starter shall have removable Phase Arms to allows rapid replacement of parts to minimize the down time
- 7 The starter manufacturers scope shall include the preparation of all detailed shop drawings for the starters, including wiring diagrams, test certificates, operating and maintenance manuals and a list of required test equipment such that the Contractor has all necessary information.
- 8 The starter manufacturer shall deliver the panels to site, assist in testing and commissioning and offer full cooperation and liaison with the Contractor in his commissioning of the connected equipment. The panel manufacturer shall provide an experienced engineer at site during the commissioning of the plant.
- 9 The panel manufacturer shall provide a 24 hour- 365 day per year emergency call-out service to guarantee to be at the site within 4 hours of an emergency call.

#### **35.6.3 Enclosure construction:**

- 1 The medium voltage solid state controller shall consist of a metal-enclosed, free-standing, dead front, vertical steel structure.
- 2 The followings minimum thickness shall apply:
  - (a) Plinth/bed frame - 3.00 mm
  - (b) Frames - 2.50 mm
  - (c) Covers and Doors - 2.50 mm
  - (d) Gland Plate - 3.00 mm
- 3 Each structure shall be suitable for future expansion at each end. Each structure shall also have (2) non-removable base sill channels and removable lifting angles or brackets for ease of handling and installation.
- 4 Provide IP 4X enclosures for indoor application.
- 5 Provide a dedicated incoming line section for each starter to accommodate the number and size of incoming cables for bottom entry. Motor cables will exit the starters from the bottom.
- 6 The controller shall be of modular design to provide for ease and speed of maintenance. The modules shall be manufactured by one Supplier and designed to allow ease of maintenance, including removal of medium voltage components and power electronic components by one maintenance personnel.
- 7 The Structure shall be divided into isolated compartments as follows:
  - (a) Main power bus and ground bus compartment
  - (b) Power cell compartment
  - (c) Low voltage compartment

- (d) Control module compartment
- 8 Metal barriers shall be provided between each vertical section, between the low voltage compartment and the power cell and/or main power bus compartment and between the power cell and main power bus compartment. Personnel shall have access to the low voltage compartment, with the controller energized, without being exposed to any medium voltage.
- 9 The controller shall accept nominal plant power AC (+/- 1%), 3 phase 50/60 Hz (+/- 3%).
- 10 Each Structure shall contain the following items
- (a) Tin plated copper horizontal power bus
  - (b) A continuous bare copper ground bus
  - (c) Power electronics
  - (d) A main non-load break isolation switch and operating handle
  - (e) A vacuum isolation contactor
  - (f) A vacuum bypass contactor
  - (g) Current limiting power fuses for NEMA Class E2 operation, as required
  - (h) MV Current transformers, as required
  - (i) A low voltage control panel complete with microprocessor based control module
  - (j) Space for necessary auxiliary control and metering devices
  - (k) Bottom plates to accommodate entry cable connectors
- 11 The isolating switch shall be an externally operated manual three-pole type, such that in the open position it completely grounds and isolates the starter from the line connectors with a mechanically driven isolating shutter leaving no exposed high-voltage components. Integral mechanical interlocks shall prevent entry into the high-voltage areas while the starter is energized and shall block accidental opening or closing of the isolating switch when the door is open or the contactor is closed. The isolating switch handle shall have provisions for three (3) padlocks in the off position.
- 12 Bypass contactor shall be provided to short out the SCR's once the motor is up to full speed. When "Stop" function is selected, bypass contactor shall open bringing SCR's back into power circuit.
- 13 Current limiting power fuses shall be of the self-protecting type with visible fuse condition indicators. The fuses shall incorporate special time/current characteristics for motor service allowing proper coordination with the contactor and overload relay for maximum motor protection. This coordination shall be such that under a low-fault condition the interrupting rating and drop-out time of the contactor shall be properly coordinated with all possible fuse sizes to eliminate contactor racing. The power fuses shall be vertically mounted, permitting easy inspection and replacement without starter disassembly. A fuse puller shall be provided with each starter.
- 14 The low-voltage control compartment shall be isolated and barriered from the high-voltage area and mounted on a panel with a separate low-voltage access door. The low-voltage control components shall be accessible from the front of the low-voltage control compartment.

- 15 The horizontal main bus shall be located in its own separate 250mm high enclosure and isolated from the starters. To allow for ease of maintenance or extension of line-ups without disassembling starters, the main bus shall be front, rear, top and side accessible. The Bus shall be rated for 50kA 3s. The Bus will be insulated. The current rating of the bus will be 1200A, 2000A or 3000A, dependent on the total bus requirements at the derated temperature, with 20% spare capacity.
- 16 Starters shall be connected by an insulated vertical bus.
- 17 All bus bars shall be tin-plated copper.
- 18 Provide a 6mm x 50mm ground bus extending entire length of controller.
- 19 The isolation between LV and MV areas is provided by using optic fibre connections. This ensures 100% safe isolation, which means guaranteed safety for the personnel.

#### 35.6.4 Control Module

- 1 Medium-voltage soft starter control module shall be microprocessor controlled digital module with remote communications capabilities and shall operate on 240Vac supply ( $\pm 10\%$  variation in voltage and  $\pm 3\%$  variation in frequency).
- 2 The control module logic shall provide one of the following sets of functions within a single controller:
  - (a) Soft Start with Selectable Kick-Start
  - (b) Current Limit
  - (c) Full-Voltage Start
- 3 The following protection shall be provided during 'Starting' and 'Running' modes:
  - (a) 49, 51 Motor Dynamic Thermal Model
  - (b) 49T Motor Thermistor Protection
  - (c) 48 Excess Start Time
  - (d) 66 Restart delay (starts per hour)
  - (e) 27 Under Voltage
  - (f) 59 Over voltage
  - (g) 81 Supply Frequency
  - (h) 47 Phase Sequence
  - (i) 37 Undervoltage
  - (j) 51-1 Instantaneous Overcurrent 150-2
  - (k) Instantaneous Overcurrent 2
  - (l) 46 Current Imbalance
  - (m) 50G Ground Fault
  - (n) 32 Powerloss
  - (o) 50 Shorted SCR, Power Circuit, Incorrect Motor Connection, Communication Failure

- (p) 68, 94 Input A and B trip

When these conditions are detected, starting of the controller shall be inhibited or the controller shall be shut down if it is operating.

4 The controller logic shall provide the following standard features:

- (a) Adjustable Ramp up Time
- (b) Adjustable Ramp down Time
- (c) Adjustable Initial Current
- (d) Adjustable Max. Current
- (e) Selectable Current Limit During Motor Start
- (f) Line Phase Loss Detection
- (g) Line Current Imbalance Detection
- (h) Over/Under Line Voltage Protection
- (i) Selectable Password Protection of Starter Parameters
- (j) Adjustable Stalled Motor Detection
- (k) Up to Speed Indication
- (l) Line Phase Sequence Sensitivity, or Insensitivity
- (m) Adjustable Motor Full Load Amperes

5 Each machine shall include a timer to prevent unit from restarting during coast down and controls to automatically and immediately reinitiate starting sequence after machine has stopped. Timer settings shall be coordinated with application manufacturers to prevent damage to equipment from frequent starts.

6 Each controller shall include a timer to prevent unit from restarting during coast down and controls to automatically and immediately reinitiate starting sequence after machine has stopped. Timer settings shall be coordinated with application manufacturers to prevent damage to equipment from frequent starts.

7 The control module shall communicate status and alarm information to the Master Controller using a Modbus RS485 link (Profibus, Ethernet, Devicenet, Profinet as option). The control module shall receive motor starting commands via hardwired signals. Coordinate communications protocol with system integrator.

8 Each Starter shall have an analogue Output 0~20 mA or 4~20 mA Selectable for motor current, motor temperature, motor kW, motor kVA, motor power factor, mains voltage Maximum and minimum range setting.

9 The Controller shall have Simulation and Commissioning/Maintenance Tools with Run simulation, Signalling simulation, Protection simulation, Low voltage testing

10 The Starter shall have an Diagnostic Board. The MV Diagnostic Board records the following waveforms:

- (a) 3 phase analog voltages (relative, not absolute values)

- (b) 3 phase analog currents (relative, not absolute values)
- (c) Output of frequency locked derived (virtual) phase 1-neutral zero crossing signal
- (d) Internal variable Phase 1 conduction period
- (e) Internal variable Half cycle count (ie MV supply period)
- (f) Internal variable Lag count (ie time difference between derived phase 1 voltage zero crossing and end of conduction.)

Data is recorded:

- (a) During a start: From the time the Start command is given to the time the starter enters the running state.
- (b) During a stop: From the time the Stop command is given to the time the starter exits the stopping state.

#### 35.6.5 Configuration

- 1 Soft Starter supplier shall supply a software tool to configure, monitor and troubleshoot the Soft Starter. Software tool shall have a trending feature where up to six signals can be displayed in real time.
- 2 The software tool shall have a multilevel access feature for configuration of parameter settings.

#### 35.6.6 Operational Controls

- 1 The Soft Starter shall include the following basic operating adjustments:
  - (a) Start/Stop/E-Stop
  - (b) Acceleration/Deceleration times, direction of rotation, jog, local/remote operation,
  - (c) Operating Modes;
  - (d) Voltage ramp
  - (e) Current limitation
  - (f) Pump control
  - (g) Torque control
  - (h) Current ramp
  - (i) Guided Starting Sequence (Oriented Startup) to minimize parameter settings
  - (j) Direct On Line (DOL) operation selection via software parameter to bypass soft start operation
  - (k) Active Motor Protection: All motor protection control should be active in case of bypassing soft start operation
  - (l) Motor thermal class curve selection without use of separate motor protection relay

- 2 Soft Starter shall include necessary instrumentation to monitor the power devices and the motor against overload, internal faults of the motor or the Soft Starter and disturbances in the incoming power supply.
- 3 Soft Starter should allow for temperature monitoring of motor windings via RTDs up to 8 signals and allow use of these temperature values as feedback to thermal class protection curve setting calculations
- 4 Soft Starter faults that result in tripping or shutting down of Soft Starter operation shall be annunciated on the removable graphic LCD keypad. The Soft Starter shall shut down safely with the output voltage reduced to zero for the following conditions;
  - (a) Under-current, Overcurrent and current unbalance
  - (b) Under-voltage, Overvoltage and voltage unbalance
  - (c) Under-torque, Over-torque and active overpower phase loss
  - (d) Reverse phase sequence
  - (e) Over-temperature in the thyristor power modules
  - (f) Motor overload or external short circuit
  - (g) Motor over-temperature (via accessory module)
  - (h) Ground fault by voltage or current.
  - (i) Fault within thyristor power modules
  - (j) Fault in the operation of power contactors
  - (k) Faults within the control boards (self-monitoring)
  - (l) Communication faults of HMI and between controls boards
  - (m) Faults in the communication networks
  - (n) Programming errors such as incorrect parameter setup, limit setting, data entry etc.

#### **35.6.7 Control Power Transformers (CPT)**

- 1 A Control Power Transformer (CPT) shall be provided within the enclosure. CPT shall be rated for generating control voltage for the Soft Starter controls
- 2 The KVA rating of the CPT shall be determined by the Manufacturer and shall have a minimum of 25% spare capacity.

#### **35.6.8 Input and Output Controls**

- 1 Discrete Interface to field controls and field signals shall be provided by the Soft Starter supplier

- 2 Soft Starter control system shall be capable of following INPUT signal interface;
- 3 Digital INPUTS: Programmable
- 4 6 Programmable Isolated Inputs: 24Vdc
- 5 Soft Starter control system shall be capable of following OUTPUT signal interface;
- 6 Digital OUPUTS: Programmable
- 7 3 NO/NC relay contacts, 240 VAC, 1A
- 8 Analog OUPUTS: Programmable
- 9 2 isolated outputs, (0 to 10V), 0 to 20mA or 4 to 20mA, 11-bit resolution
- 10 If specified, a communication network to the Purchaser's network shall be MODBUS, Ethernet or Profibus.
- 11 The drive shall facilitate configurable controlled-stop (within a maximum of 30 sec.) of motor & load without causing any damage or tripping of the Drive.

#### **35.6.9 Faults and Alarms**

- 1 The latest 10 faults and alarms are logged and time stamped with date record. The trace data can be uploaded to PC tool for display/analysis in the trend window.

#### **35.6.10 Emergency Stop Control**

- 1 An Emergency-stop (E-Stop) shall be provided on the soft starter door in addition to inputs for customer supplied E-Stop command to ensure effective direct stopping of the drive if dangerous situations arise. The means provided should include direct connection to a contractor, Breaker, arranged such that its opening on-load:
  - (a) does inhibit any in-built deceleration provided by controller
  - (b) does not produce additional safety hazards
  - (c) does not cause damage to the controller.

#### **35.6.11 Metering**

- 1 An additional relay shall be mounted to measure the corrected power factor and should measure current through metering class CTs. The meter should also measure current and voltage in all three phases, power factor, power (kW), kVAR, kWh and THD (%).Real time performance graphs for showing parameters (e.g. motor current), with selectable time base (10 s~ 1 h)

## 35.7 INSTALLATION

### 35.7.1 Documentation

- 1 The following documentation shall be provided:
  - (a) load de-rating (with tender)
  - (b) harmonic distortion (with tender)
  - (c) circuit diagrams
  - (d) maintenance instructions
  - (e) fault diagnosis
  - (f) parts list with part numbers
  - (g) commissioning instructions
  - (h) general arrangements drawings
- 2 A recommended spares list for two years continuous operation shall be submitted at the time of tender. Where multiple, identical units are being supplied a rationalised list, i.e. not a summation of individual drives, requirements, should be produced.

### 35.7.2 Commissioning

- 1 The manufacturer shall have a factory trained service representative residing in Qatar for commissioning, programming and to provide training and after sales service.
- 2 The representative shall be trained in the installation, maintenance and trouble-shooting of the equipment specified and shall assist the Contractor to set-up and commission the soft starter.
- 3 The integrated site test on the Soft Starter, motor and all other associated devices shall be conducted to verify the input and output current, voltage, frequency, power factor, acceleration and deceleration rate etc. in accordance with the operating characteristics as approved by the Engineer.
- 4 Test at different operating conditions by adjusting parameters (25, 50, 75 and 100%). Record the performance and verify.
- 5 Tests shall be performed during normal plant operation and during operation with the emergency generator.
- 6 The manufacturer's engineer or their trained and qualified engineer working full time with the local supplier shall conduct all tests on site.
- 7 Upon completion of site tests a duly signed report listing all tests and checks, together with all supporting documents and drawings where applicable, shall be submitted to the Engineer for review. The Owner's representative shall be invited to witness the tests.
- 8 Submit all test reports, drawings and supporting documents to the Engineer and obtain written approval from both prior to the system being accepted by the Owner.

### 35.7.3 Training

1 Duration of training shall be minimum 10 days for two client persons at the manufacturing facilities. The training shall include:

- (a) Theory of operation
- (b) Layout and component level study
- (c) Hands-on training on assembly & configuration of the drive
- (d) Installation & commissioning procedures
- (e) Hands-on training on trouble shooting and working with various components
- (f) Routine maintenance practices
- (g) Spare part ordering & inventory control.

END OF PART