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1.General

1.1.Scope

This document covers the minimum technical requirements and criteria for design of 12005.B.ME.DCA.303.GNL.001 & 12005.B.PI.DCA.303.GNL.001 in " Project "

This specification covers the minimum technical requirements, design, procurement, manufacture, quality control, testing, inspection, spare parts engineering and transportation of Technical Specification for MV/LV variable frequency drives to the site location.

It is basically a performance-type specification and covers only those general aspects that are considered minimum quality and performance requirements by the purchaser.

More detailed and specific data are contained in the drawings, data sheets and other documents that form the tender.

Standard design and models from bidders manufacturing program will be accepted in case they meet the requirements of this specification and serve the intended purpose.

If a substantial improvement of any or all of the specified requirements expressed or implied herein is available from bidder, and this improved design offers economic advantages to purchaser, this should be proposed as an alternative together with basic proposal that conforms to this specification.

All equipment described in this specification are intended for continuous duty at the specified ratings under specified service conditions.

Compliance of the manufacturer with the provisions of this specification does not relieve him of the responsibility of furnishing Technical Specification for MV/LV variable frequency drives and accessories of proper design electrically and mechanically suited to meet the operating guarantees at the specified service conditions.

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1.2.Definitions

Throughout this document the following words and expressions shall have the meanings hereby assigned to them except where the context otherwise requires:

- “CLIENT”
- “BUYER”
- "BUYER
- “SUPPLIER &/OR Contractor” means the firm or company which the contract will be made with.
- “SUB-SUPPLIER” means any person or company (other than the supplier) named in the contract for any part of the works.
- “WORKS” means all obligations of the Contractor described in the "scope of works" of this document.
- “PLANT” means Project
- “APPROVE” means approval in writing letter confirmed by buyer.

2.Codes and Standards

The equipment covered by this Specification, including all components and auxiliaries shall be designed, manufactured and tested in accordance with the latest IEC Standards wherever they may apply, and in particular: unless otherwise specified, the design, equipment, materials, installation, inspection and testing shall be conformed to the requirements of the latest edition of the followings:

- IEC61800-5-1: Adjustable speed electrical power drive system – part 5-1: safety requirements – electrical thermal and energy
- IEC 61800-5-2 Adjustable speed electrical power drive systems - Part 5-2: Safety requirements – Functional
- IEC61800-3: Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods.
- IEC 61800-4 Adjustable speed electrical power drive systems - Part 4:
- General requirements - Rating specifications for a.c. power drive systems above 1000 V a.c. and not exceeding 35 kV

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- IEC61000-4 Electromagnetic compatibility (EMC) - Testing and measurement techniques
 - IEEE 519 Recommended practices and requirements for harmonic control in electrical power systems
 - IEC 61800
 - Converter transformers in compliance with IEC 61378
 - IEC 60321-3-3 Guidelines for network Auxiliary printed board information
- Furthermore, the parts shall also comply with the regulations and standards as required by the local laws regarding the prevention of accidents and with all the applicable European directives especially with the electromagnetic compatibility ones.
- IEC 60146 Semi-conductor converters
 - IEC 62262 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

Note: Electrical equipment shall be designed, manufactured, erected, and installed according to the latest editions of the IEC (International Electro technical Commission) standards.

Minimum requirement for installation shall be follow local codes and norms. In lack of them normal European industrial practice is followed. Other standards that can use in reference, but shall be equivalent with IEC standard, are as below:

BS-IEEE-ANSI-VDE -DIN -ISO -NEMA-NFPA-NACE-API-ISA-NACE

3.Conflicting Requirements

In the event of conflict, actual or implied, among documents relating to an enquiry or order, following order of precedence shall govern, unless agreed in writing by Buyer.

1. Material Requisition
2. Data sheet
3. Drawings
4. specification

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5. Design Criteria

6. Code and standards

7. In any case the vendor shall inform purchaser and obtain clarification before proceeding with any work.

The Vendor shall notify the Buyer of any apparent conflict between this specification, the Codes and Standards and any other specification noted herein. Resolution and/or interpretation of precedence shall be obtained from the Buyer in writing before proceeding with the design/manufacture.

Alternatives proposed by the Supplier will receive careful consideration if they improve performance and reliability.

4.Site Condition and Utilities

4.1.General Site Location

4-1-1

- Elevation: about 2500 meters above sea level.
- Barometric Pressure: 564.4 mm Hg

4-1-2- Temperature:

- Max. (Summer): 35° C
- Design Max (indoor and outdoor) 40° C
- Min. (Winter): -25° C
- Design Min.(outdoor) -25° C

4-1-2- Relative Humidity:

- Humidity: 30 % @ 33°C
- Max.: 70 %
- Min.: 23 %

For specific indoor area (above open sumps and flotation cells and above thickeners) due to special condition (water evaporation and water spraying) relative humidity shall be considered 100 %.

4-1-3- Wind Condition:

- Max. Wind Velocity already recorded: 100 Km/h

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- Prevailing Wind Direction:
- Winter: Between South and South West
- Summer: Between North and North East
- Stormy days per annum: 10

4-1-4- Rainfall:

- Average: 500 mm/a
- Design: 500 mm/a
- Rainfall Intensity: 76 mm/h

4-1-5- Snowfall:

- Average: 100 mm/a (as water)
- Design Intensity: 150 mm/a (as water)
- Frost Line: 1200 mm below grade

4.2.Site description

4-2-1- Lithology:

The Site lithology consists of colluviums or slope wash overlying a deep volcanic weathering profile.

The Site lithology is summarized in below table:

Unit	Description	Top of Unit (m)	Approx. thickness (m)
1	Colluvium/ Slope wash	Surface	1-3
2	Residual Solids	3	5-10
3	Volcanic Rocks	10	>10

4-2-1- Seismicity:

SITE is classified as a high hazard zone and the above standard shall be considered during design of all foundation, structures and buildings.

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5.MV VFD Specification

5.1. Electrical Data

service voltage Un:	6.6kV
insulation voltage	12kV
industrial power frequency test voltage for 1 min.:	28 kV power circuits 2k V auxiliary circuits
Rated impulse withstands current: Permanent voltage tolerances:	75 kV ± 10% of Un
Frequency:	50 Hz ±5%
Motor power size:	Will be finalized later
Neutral state: VFD rated current	grounded through a resistor # A ¹
nominal continuous power:	according to rated current
maximum consecutive starts	2/1 (cold/warm)
bus-bars rated current:	according to the rated current
short-lasting current for 1 sec	Refer to data sheet
dynamic rated peak current:	100kA
internal arc withstand current: internal arc classification: loss of service category: class of partition: auxiliary circuit voltage	40 kA for 0,5” AFLR LSC-2A PM/PI anti-condensate, lighting and fans circuit 230Vac signalling lamps 230V ac UPS 0,5”

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Cooling System for Power Transformer & IGBT	Air Cooled / water cooled / forced air
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6.Mechanical Data

The external degree of protection of the panel shall be IP41, while the degree of protection inside the auxiliary device’s cubicle shall be IP4X. Climatic condition shall meet 3K3 class. Degree of pollution will be 2 without conductive pollution in accordance with IEC 61800-5. Other mechanical conditions will be class 3B1.

Sound pressure shall be less than 70dB (A).

Definition of availability

Availability is defined as:

$mtbf/(mtbf+mttr)$ (Hours) :

Mean time between failure- MTBF, Mean time between failures is defined as:

$operating\ time/(number\ of\ faults\ that\ have\ resulted\ in\ outage)$ (Hours).

Mean time to repair - MTTR, Mean time to repair is defined as:

$(time\ to\ repair\ and\ to\ come\ back\ in\ service)/(number\ of\ faults\ that\ have\ resulted\ in\ outage)$ (Hours).

Note: The above MTBF and MTTR definitions are based on statistics and are valid only under the following conditions:

- At least one period of four-year operating time of at least 4 pieces of similar equipment (but excluding the first 3 months of initial operation of the VFDs) shall have been experienced.
- MTTR shall only relate to VFDs repair- The MTTR time shall include a maintenance overhaul time of 80 hours over a 2 weeks period after 4 years of operation.

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- Operation of the VFDs shall have been in accordance with Manufacturer's instructions, assuming qualified staff and materials to be available at the work site.

7.Construction Characteristics

7.1.General

The panel consists of standardized cubicles located side by side, each of which is made of fit together and standardized units.

Each cubicle is made of sheet steel 2.5 mm. thick, the panels and the doors are made of sheet steel 2 mm. thick:

Each cubicle consists of compartments containing the various electrical and mechanical components as described below, which are separated by sheet steel partitions.

The following typical compartments can be seen in the panel:

- Transformer cubicles
- Power cells cubicle
- Controller cubicle

Filters shall be considered on the line side in case harmonics on the line input.

Arc-proof panel is normally provided for evacuation of the gases produced by an arc.

To provide as high a degree of protection as possible by evacuating the effects of internal arcing switchboard, there shall foresee evacuation systems which direct gases towards the top of the switch board enabling over pressure to be limited in the case of an internal fault in the compartments; supplier shall specify the configuration of the proposed panel.

All the compartments are accessible from the front and maintenance operations can correctly carried out with the switchgear installed up against a wall.

The drive shall be of modular design to provide for easy and speed maintenance.

Metal or plastic barriers shall be provided between each vertical section and between the low voltage compartment and the power cell. Personnel shall have access to the

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low voltage compartment, with the VFD energized, without being exposed to any medium voltage.

The panel shall contain a power cable termination assembly designed for easy termination and access to line and load cables. The termination assembly cabinet shall allow for top and bottom entry and exit of line and load cables.

For safe maintenance a mechanical interlock, on the transformer cubicle door, with the upstream CB shall be provided; other panel doors shall be provided with electrical or mechanical protections to avoid any possible hazard for the operators.

7.2.Bus-Bars and junctions

Two main bus-bar systems are provided for line and power cells; bus-bars are preferably made of bare copper. The bus-bars system shall be designed to withstand the required short circuit currents, (thermal limit for 1 second/peak volume range) defined in the electrical data.

7.3.Insulating materials

The insulating parts shall be designed to guarantee resistance to pollution and ageing.

All the insulating materials used in the construction of the panel are made of self-extinguishing type and shall be chosen with particular attention to the resistance against the surface discharge and with anti-tracking qualities.

7.4.Earthing system in the panel

An electric copper drop bar with a minimum cross-section of 120 sq. mm. runs longitudinally through the panel and is securely bolted to the metal structure.

The whole structure and all the steel structural elements are firmly connected to guarantee a secure electrical contact between the parts.

The doors are connected to the metal structure by means of flexible copper plaits with a minimum cross section of 16 sq. mm.

Each end of the drop bar is provided with terminals suitable for connection by cable to the substation earthing system.

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7.5.Paint

The whole of the metal structure of the cubicles is suitably treated and painted in order to provide excellent resistance to wear; manufacturer painting cycle is acceptable.

The final color of the paint is defined by this specification in the mechanical characteristics while the internal zinc-plated parts are not painted.

The switchboard shall be provided with side panel painted closures.

7.6.Equipment

The main pieces of equipment assembled in the panel shall be suitable for the characteristics of the project as above specified and with the following chapter of this specification.

7.7.Transformer

Transformer should be used as a robust way to cancel input current harmonics without the need for input harmonic filters or a complex active front-end, protects power converter semiconductors against line transients, for kinetic buffering, for complete protection of the motor in case of a ground fault in the drive, the motor cabling or insulation. Negligible common mode voltage allows the use of a standard motor, thus eliminating the need for special high-voltage insulation; then limits the fault energy in the drive in the unlikely event of a fault and the incoming line voltage doesn't have to match the motor voltage.

The dry-type transformers should be force-ventilated and specifically designed for use with the drive type and have extended delta secondaries; in this case the secondary currents are rich in harmonics, but the primary current is virtually sinusoidal.

In case the transformer shall be installed outside from the VFD panel, oil or dry type, the supplier shall inform within the offer specifying the relevant detailed technical characteristics.

The transformer winding should be considered with copper conductor.

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7.8.Power cells

Medium-voltage levels are obtained by adding together the outputs of multiple low-voltage power cells. The low-voltage power cells are simplified variations of standard 2- level PWM motor drives for low-voltage service. For higher output voltages, more power cells can be connected in series in each phase. The number of secondary windings of the input transformer increases accordingly.

Insulated Gate Bipolar Transistors (IGBTs) form the backbone of the drive; the stability and reliability of IGBTs ensure a long service life and a high degree of availability.

The modular configuration of the power cells gives many advantages when it comes to maintenance, power quality and reliability. Power cells can be pulled out easily voltagefor maintenance having front accessible connections.

7.9.Auxiliary equipment and accessories

The panel shall be complete with all the protection, metering, control and signalling equipment as below mentioned, and which are necessary to make it ready for immediate use. The panel shall be complete with the following accessories:

- Plastic nameplates with white engraving
- attention signal plates
- eyebolts for lifting
- levers and special accessories for assembly, maintenance and operating if required

7.10.Wiring

All the auxiliary control and signalling circuits shall be wired with flexible copper conductors insulated with PVC that prevents fire from spreading and which has a minimum cross section of 1.5 sq. mm. (excluding the contactors internal control circuit and analogical signals for which a cross section of 1 sq. mm. can be provided). The ammeter circuits shall be wired with the same characteristics as those described above, but they have a minimum cross section of 2.5 sq. mm. All the auxiliary circuits that cross the medium voltage zones shall be protected by suitably earthed metallic

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cover or pipe. All the ends of the conductors shall be numbered with related plastic ferrules and provided with terminals.

All the conductors of the circuits related to the equipment contained in the panel are joined to numbered fit together terminal boards.

The insulating support of the terminals is made of fireproofing material that is non-hygroscope. The clamping of the terminals in the connecting terminal is of anti-vibration type for the connection on the customer's side.

The delivery terminal of the amperometric circuits shall be short circuited type.

The terminal strips used for the connection of the external cables shall be designed to permit the wiring of only one conductor to each terminal; a number of additional terminals equal to 10% of the used terminals shall be provided. All the equipment fitted in the controller cubicle that is usually live, shall be protected with an easily removed insulating screen which prevents from accidental contact with live circuits.

8.VFD Main Characteristics

8.1.General operational specification

The electrical characteristics are already shown at chapter 3; other main characteristics are below described.

The VFD shall enable to start and run one of the two motors at a time (with prior selection), synchronize it with the network and connect it across the line; then go for the next motor and repeat the sequence.

The VFD shall produce a variable voltage and variable frequency output to provide continuous operation over the application speed range. The VFD shall be capable of operating with the output short circuited at full current or with the output open circuit at rated voltage. VFD shall be capable of operating one standard AC squirrel cage induction motor of equivalent power and speed rating over the speed range specified in the data sheet.

Drive system shall reduce common-mode voltage at the motor stator windings, minimizes drive induced torque pulsations and associated torsional analysis using a

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fine motor pulse width modulation (PWM) output. The drive system shall supply a sinusoidal output to eliminate additional harmonic heating and can be used with new or existing motors without derating.

The drive system shall provide controlled speed over the range specified. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.1% of base speed without encoder or pulse tachometer feedback.

The VFD shall have a “normal duty” rating of 100% continuous current with a short time duty rating of 120% overload for one minute, once every 10 minutes (suitable for variable torque loads). A “heavy duty” rating shall be available with 100% continuous current with a short time duty rating of 120% overload for one minute, once every 10 minutes (suitable for constant torque loads). The VFD shall be capable of 100% breakaway torque without tachometer feedback.

Air-cooling shall be provided with a mixed flow cooling fan, mounted on the VFD enclosure. The VFD shall include air-flow pressure switches and temperature detectors to monitor proper operation of the air cooling system. If a fan fails, the system must generate alarm indication of the fan failure. Vane type air-flow switches are not acceptable. Drive shall be equipped with facilities for the connection to an external air discharge system.

8.2.Motor compatibility

The VFD shall provide near sinusoidal voltage and current waveforms to the motor at all speeds and loads. Output current THD shall be shall be in accordance with IEEE519.

Standard induction motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.

The motor insulation system shall not be compromised thermally or due to dv/dt stress. dv/dt at the motor terminals (line-to-line) shall be limited to 1000V/μsec. If dv/dt at the motor terminals (line-to-line) exceeds 1000V/μsec, the vendor must state

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the actual value in the attached data sheets and include steps taken to guarantee the long term life of the motor insulation system as dv/dt filters.

The motor insulation system shall not be compromised due to excessive peak voltage of the output waveform. Motor peak line-to-line output voltage shall be limited to the following values:

Line-to-Line Stator Rated Voltage (Vac RMS)	Peak Line-to- Line Output Voltage (Vpk)
3300	4667
4160	5883
6000	8485
6600	9334
10000	14142
11000	15556

If the motor peak line-to-line output voltages exceed the values listed in the above table, the vendor shall clearly state the actual value with the proposal.

Expected Dv/dt value shall be ≤ 1000 V/μs; higher values up to 3000 V/μs could be accepted after verification of the motor windings capability. Supplier shall detail information within his proposal.

The VFD shall provide stable operation of the motor without compromising the motor insulation system, regardless of motor cable distance. The vendor shall clearly state the limitations in motor cable distance with the proposal. If an output filter is required to mitigate reflected waves, or to meet any special requirements of the application, it must be integral to the VFD controller. If output filters are used in the VFD, harmonic elimination feature shall be available to eliminate a potential harmonic resonance in the operating speed range. VFD induced torque pulsations to the output shaft of the mechanical system shall be less than 1% to minimize the possibility of exciting a resonance.

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8.3.Line and output harmonics

Drive system shall meet IEEE 519 harmonic guidelines with the lowest possible design complexity. The VFD supplier shall detail the number of main power components supplied in the VFD and number of secondary windings on the isolation transformer specifying in the proposal the expected value of voltage and current harmonics (THD) on the line side.

It is acceptable for VFD which operate in over-modulation in the 95 to 100 % speed range, that higher output voltage and current harmonics are present for the 5th and 7th harmonic frequencies. This is reflected in the THD and torque pulsation values but values shall remain within following values.

8.4.Power electronic configuration

Following configuration requirements are the minimum acceptable for the equipment.

Power semiconductors: diodes, IGBT

line side rectifier (minimum): PWM rectifier (Active Front End) with AC line reactor or isolation transformer 12-pulse rectifier with 3 winding secondary phase shifting isolation transformer or up to 36 pulse with internal built in transformer .

motor side inverter: Multi-level drive (PWM) with IGBT power modules

closed loop control: sensorless closed loop control 2

drive quadrants potential: fiber optic cable (power section/ open and closed- loop control)

power factor air: ≥ 96 % including transformer, across whole power range

cooling: $\geq 0,97$ lag across whole power range forced air

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8.5.Control system and protection

output frequency	0 ... 300 Hz; supplier shall specify for which frequencies current derating is required
modulation	multi level PWM
ride through	medium-voltage ride-through: > 5 cycles power sag ride through: sag of 30% on nominal voltage of the input line ⁶ control power ride-through with UPS: > 5 cycles
rotating motor	Instantaneous mode: allows fast bypass frequency scan mode: performed after residual motor voltage has collapsed
induction motor control	V/f control
	vector control for induction motors without encoder , vector control for induction motors
auto tuning	available from a certain motor power drawn from the drive

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synchronous transfer	the VFD control system shall include a synchronizing regulator to adjust the drive speed reference as required to synchronize the motor to the line. Voltage inputs (100V) for the operation are provided from the main MV switchboard. The following list of adjustable parameters for synchronous transfer control could be considered as a basic requirement: Synchronous Transfer Lead Angle Synchronizing Regulator Gain Synchronizing Regulator Error Synchronous Transfer Mask Synchronizing Time Synchronous Transfer Time Synchronous Transfer Off Delay
motor and soft starter protection	complete protection with following functions to detect low and high impedance faults. A "low impedance" fault in the drive or the secondary side of the transformer would result in a significant reactive current on the primary side. A "high impedance" fault in the drive would result in low current that is difficult to detect on the primary side of the transformer but will result in measurable losses that can be used to detect the condition. During normal run the motor is fed from the by-pass circuit breaker while the line circuit breaker which supply the VFD; the motor protection is made by the microprocessor relay installed on the by-

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	pass feeder. Following protection should be provided by the VFD during its operation: over and under gate voltage loss of gating phase loss and sequence under and over frequency under and unbalanced current ground fault rotor stall thermal I2t protection tor stall too many starts and start inhibit time motor over speed IGBT shorted heat sink overtemperature starter over temperature control power over and under voltage Ventilation loss
diagnostic	Diagnostics complete system diagnostics on the operator panel remote signalling by voltage free contacts for trip conditions (no.2 contacts for each)
interface signals	On board I/O card as minimum shall have 20 digital inputs, 16 digital outputs, 3 analog inputs and 2 analog outputs. As minimum VFD system shall provide following features by means of voltage free contacts; details will be defined during engineering stage: ready to start (no.2 out contacts) starting / running condition (no.2 out contacts) emergency stop feed back (no.1 out contact) Line, motor supply and DOL by-pass circuit breakers close/open command (out 1=close; 0=open command) Alarm and Fault signal (no. 2 out contacts) remote emergency trip (no.1 in contacts NC) managing of the following external signals (inputs): remote start, remote stop, remote inhibit, remote reset; line, motor supply and DOL by-pass circuit breakers position (open/close)

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8.6.Operator interface and communication

The VFD shall have a user-friendly operator interface terminal with the following minimum features:

- Large LCD display screens (10" 16 line – 40 characters) that are easy to read and provide information of drive operating status
- User configurable metering for motor and line characteristics
- Extensive diagnostic functions that provide separate fault and warning queues in non-volatile memory that retain information under all conditions
- On-line help that provides enhanced fault text messages
- Trend buffers for at least 8 variables that allow one-shot or multi-shot trending
- Multi-level password access to ensure that only qualified personnel have access to critical parameters but still allow easy access to other levels of personnel
- Extended use of plain language messages to eliminate need to look up error codes or decipher the meaning of error messages
- Start-up wizard, including auto tuning, that is

interactive and user-friendly Language uses for the operator interface will be English.

The VFD shall be provided with digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system. The communication protocol shall be MODBUS TCP/IP or PROFINET based on the Ethernet network.

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8.7.VFD Motor Starting Panel

It is composed by the following cubicles:

VFD unit to have fully automatic, controlled, safe and protected starting of motor complete with transformer, incoming/outgoing cable compartments and terminals including line/motor side filters if required after detailed analysis of harmonics and overvoltage, dv/dt characteristics. All required facilities and equipment shall be provided.

Panel shall be equipped with anticondensate heater, internal lighting and all other features according to what above described.

All tools, software and special cables necessary for the configuration, operation and maintenance activities shall be included in the scope of supply.

Line, motor supply and DOL by-pass circuit breakers installed in the MV panel shall be managed by the VFD starting control system synchronizing the drive voltage with the line voltage to have the fully smooth and right operation of the motor.

9.Technical Services

Together with the supply, supplier shall provide, as minimum, the following technical documentation concerning the products which included the supply.

All the documentation will be in English language. It's also required to have an electronic copy (CD media); the technical documentation it's required in .DWG or .DOC/.XLS formats while the other documents can be in .PDF format.

The operator panel shall also be in English language.

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9.1.Technical documentation

- general assembly *
- single line diagram *
- wiring diagram *
- terminals list with cables for all panels *
- list of materials for each panel (not typical) *
- utilities list including heating losses information *
- communication interface database list *
- equipment for commissioning
- commissioning spare parts list
- capital spare parts
- protection set-up parameter list
- motor start-up study *
- Spare parts for two years operation
- Special tools

All the documents countersigned with * shall be sent for approval, before the construction; the documents shall be upgraded in “as built” revision after the supplier acceptance test and before the shipment of the panels.

All operating manuals and diagrams shall be in English language as well as for the nameplates or operator interface panel.

9.2.Manuals

- Installation, exercise and maintenance manual for the soft starter
- data-sheets and manuals of the installed equipment's if any

9.3.Quality documentation

- inspection plan of the supply *
- functionality test report of VFD operation
- routine acceptance test of the supply according to the IEC standard

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- quality certificates of the main components and of the panels
- conformity declaration to the IEC standards and to the technical documents and order

panel type test certificates (copy with the offer) Drive factory acceptance test at supplier shop shall be foreseen.

All the documents countersigned with * shall be sent for approval before the construction and included in the final manufacturer data book.

9.4.Commissioning and training (optional)

9.4.1.Start-up commissioning

Start-up will be performed at user's site; supplier shall provide within its offer information regarding the start-up plan, schedule and installation requirements.

During the commissioning as minimum following activities shall be provided:

- mechanical and electrical inspection of the whole drive;
- verify and adjust critical mechanical interlocks and connections for proper torque requirement
- check of all internal connection within the drive and verify interconnection wiring with other panels/equipment
- set up all driver internal power supplies and control circuits
- verification of proper phasing from isolation transformer and line feed
- make insulation test for all cables
- perform operational checks including synchronous transfer (cold test)
- motor rotation test and tuning of the drive to the system attributes
- motor start-up test to verify proper performance of the acceleration and synchronous transfer to the line

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9.4.2.Site training

The supplier during the site commissioning shall provide for user's personnel specific training to the system installed at the facility.

The Supplier shall outline the training session duration and content; manuals and documentation shall be provided for each participant.

Training shall cover the following minimum topics:

- Basic motor theory
- Theory of operation
- Drive hardware
- Drive firmware
- Cooling system operation
- Operator interface
- Board replacement procedures
- Power device replacement procedures
- Fault analysis and troubleshooting
- Preventive maintenance procedure

10.LV VFD Specification

10.1.General

This specification covers the Design, Manufacturing, Assembly, Supply, Inspection and Testing at Works, Dispatch to Site, Site Start-up, Supervision of Erection & Commissioning of electrical equipment covered under this specification.

Vendor shall be design and granted V.S.D According the Site condition and consider ambient temperature and altitude derating.

Electrical equipment offered shall be complete in all respects. Any materials or accessories which may have not been specifically mentioned, but which are

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usual or necessary for satisfactory and trouble-free operation and maintenance of the equipment, shall be furnished by the VENDOR without any extra charge to the PURCHASER.

Supply of Commissioning Spares as required.

VENDOR to recommend spares for two-year trouble-free operation along with its unit prices.

The equipment and materials shall confirm to the requirements of the latest issues and most recent revisions and amendments of the relevant standards.

This specification covers the Design, Manufacture, and Inspection at manufacturer’s works, delivery to site and commissioning of variable frequency drive panels for the speed control of 3-phase squirrel cage induction motors. The equipment offered shall be complete in all respects and material or accessories which may not have been specifically mentioned in this specification but are necessary for satisfactory, safe, trouble free operation shall be included in the offer.

PURCHASER shall provide power supply (400 V +/- 5%, 3-phase and Neutral, 50Hz) at the incoming terminals of the VFD panels supplied by the VENDOR. All other levels of voltage (if required) and further distribution to other consumers inside VFDs shall be the scope of the VENDOR.

10.2.Basic Requirements

The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

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10.3.Performance Requirements

10.3.1.Basic Features

All low voltage equipment shall be designed for continuous duty energized from a 3 Phase, solidly grounded, 50 Hz power system with a nominal voltage of 400 V. Voltage may vary $\pm 10\%$ and frequency may vary $\pm 5\%$.

The system shall be energy efficient with minimum efficiency 92% at full load, provide very high reliability, high power factor, low harmonic distortion, low vibration, wear and noise. It shall be easy to install with minimum time and expense and no special tools shall be required for routine maintenance.

The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristic of the load, with the input supply variation of $\pm 5\%$. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short circuit.

The drive system shall be designed to operate in one or more of the following operating modes to meet process requirements.

- a) Variable torque changing as a function of speed; i.e. Speed squared.
- b) Constant torque over a specific speed range.
- c) Constant power over a specific speed range where the torque decreases when the speed increases.

The drive controller shall be equipped with microprocessor based digital regulator with programmable functions.

The power control regulator logic shall provide for acceleration/deceleration current limits curves and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

The system shall be suitable for single quadrant operation and the speed variation shall be with range 10:100 unless otherwise specified with speed set accuracy of $\pm$

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1% of rated maximum frequency and steady state regulation of +/- 0.5% of rated frequency.

The Total Harmonic Distortion (THD) of the voltage and current at inverter output shall be as per IEEE519 and the same shall be considered in the design of the motor. The system shall be suitable for operation on a supply system with a short circuit rating as calculated based on the converter transformer (if provided).

The controller output overload capacity shall be 150% of rated current of motor for 10 seconds for variable torque applications and 110% of rated current for 60 second for constant torque applications. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and the voltage to the motor to guard against overload. If the load demand exceeds the current limit for more than 60 seconds, the drive shall shutdown to prevent motor overheating and drive damage.

During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in set point within a time limit of 5-120 seconds.

The integrator action of the set point alteration shall be independently adjustable both as upward and downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.

It shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation. Short time voltage dips up to 80% of nominal, shall not cause the control system to stop functioning.

The drive shall trip in case of speed exceeds 105% of the maximum operational speed and reduce to 90% of the minimum operational speed for more than 10 seconds.

Maximum noise level from the drive at one-meter distance, under rated load with all normal cooling fans operating shall not exceed 70 db.

Variable speed drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and trouble shooting. Noise levels shall be in accordance with IEC 60034-9. Suitable silencers shall be provided as required to limit the motor noise level to conform the above limits.

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Motors for VFDs will require de-rating, depending on the speed turndown ratio. The driven equipment vendor shall confirm the motor DOL start kW rating and the motor rating for the VSD duty with the bid document.

Motors shall be selected from the standard range of motors. They shall not be specially wound to improve the efficiency of the motor/ drive combination.

10.3.2.Control Requirements

The system shall be equipped with an automatic restart facility which will restart the system in the case of voltage of over 20% or power interruptions for less than one second with recovery of the voltage to 90% of its nominal value. The drive shall have the facility to block the automatic re-start. Upon restart, the VFD shall be capable of synchronizing onto a rotating motor, so called “flying start” and develop full acceleration torque within 10 seconds.

The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

The drive motor shall be speed regulated corresponding to 4-20 mA reference input signal. Upon complete loss of the user’s speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to the loss of signal.

It shall be possible to vary the speed of the drive in either manual or auto mode.

- a) With the selector in “Manual” mode, the operator shall be able to set the speed through the keypad, which is mounted on front of the drive panel, or from speed increase/ decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.
- b) With the selector in “Auto” mode, speed of the motor shall be controlled from a 4-20 mA signal, from Client’s PLC/ DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VSD panel.
- c) The required provision for the interface with PLC/DCS (located at remote

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control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication with the industry standard open protocol i.e. MODBUS/ Data Highway Bus/ RS-485 etc. (as per IEC protocol) and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with Client's system (software) shall be provided.

- d) The starting, running and stopping logic of the system shall produce potential free contacts wired to terminals for connection to other systems.

10.3.3.Cooling

The cooling system shall include well-dimensioned panel, adequate cooling air flow path and module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and the flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans shall be provided and system shall be shut down in case of ventilation system failure.

10.3.4.Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shutdown of the system shall be available for a period of minimum 4 days (96 hours) after a shutdown even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energization. Auxiliary supply to the system components or to the electronics (firmware) for diagnostic/ display shall be taken care by the manufacturer for this purpose.

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10.3.5.External Control Unit

Control supply for devices external to VFD module i.e. Contactor's control, space heater for motor/ VFD, indicating lamps etc. shall operate on 230 V, 1-phase, 50 Hz. A switch-fuse shall be provided in the primary, MCB in secondary located inside the drive controller.

10.4.Equipment Specification

10.4.1.Power Converter

The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter.

The rectifier may make use of thyristor diode combination for 6-pulse rectification. In case 12-pulse rectification is used for the purpose of line harmonic limit, the details of the rectifier and three winding transformers shall be furnished for Client's review.

Normally, for all output short circuits, the inverter shall interrupt the current before any semiconductor fuse blows. For internal short circuits, semiconductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuse less design, the feature shall be limited to the particular device without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

All power converter thyristor design shall include coordination by peak voltage protecting snubber networks and di/dt and dv/dt circuits.

The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range.

The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

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The conversion devices and the associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/ tools.

The cooling system of the electronic components if provided shall be monitored and alarmed before the occurrence of any consequential damage to the power control devices.

The power transistors, thyristors and diodes shall be protected high speed semiconductor grade fuses. Full particulars of the power controller devices and the fuses shall be provided along with the calculations in support of the selection of fuses. Inverters shall be of latest technology.

10.4.2.Harmonics

Harmonics of the supply side of the drive system shall be restricted on the maximum allowable levels of current and voltage distortion as per recommendations of the latest edition of IEEE-Std-519. The limited values of the percentage voltage and current harmonics achieved with the given upstream system as per single line diagrams furnished, considering input point of the drives as the PCC (Point of Common Coupling) shall be furnished.

10.4.3.DC Link/ AC Line Reactor

Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and the inverter portion of the converter and to limit fault currents in this circuit. AC line reactors, if available as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.

The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled, operation of fans shall be monitored. Drive system shall shutdown in case of failure of fans.

Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature.

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10.4.4.Output Filter

VFD output current waveform shall be inherently sinusoidal at all speeds, with a total current harmonic distortion (THD) shall be in accordance with IEEE519 over the complete speed range regardless of loading. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge reduced to less than 50 V DC within 60 seconds after a loss of AC voltage.

VFD shall inherently protect motor from high voltage dv/dt stress, independent of cable length of the motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

10.5.Enclosure Construction

The AC drive shall be suitably housed in sheet steel panels and shall be fabricated with 2 mm thick cold rolled sheet steel and structural steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of protection as IP 42. The maximum and minimum operating heights of the switches shall be 1800 mm and 300 mm respectively.

The cable entry shall be from the bottom of the panel and a removable bolted undrilled gland plate shall be provided with double compression type glands. Clamp type terminals shall be used for connection of all wires up to 10 sq. mm and terminals for higher sizes shall be bolted type suitable for cable lugs. Minimum space for cable termination shall be 200 mm clear.

Bus bars shall be copper and sleeved. All the live parts shall be shrouded to ensure complete safety to personnel intended to carryout routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and the terminals shall be properly numbered. Minimum 20% spare terminals shall be provided.

All the fuses for power circuits of semi conducting devices shall be fast acting semi conducting type and mounted inside the panel. All the power and control switches shall be mounted on the door and shall be operable externally. The entire analogue

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instruments, where provided shall be switchboard type, back connected, 72 x 72 mm. Scale shall have red mark, indicating maximum permissible operating range.

Each panel shall be protected with illuminating lamp (11 W) with switch and fuse.

230V, 13 A switched socket outlets shall be provided. Each panel shall have space heater with fuse and variable setting thermostat.

All metallic components/ parts shall be connected to the main earth bus bar running at the bottom of the panel and minimum 2 x (100 x 10) mm copper bus bar (will be sized by vendor) shall be provided with extension on both sides outside the panel and provision for connection to plant earth grid. Based on the vendor’s system design, in case a separate earth bus for electronic control system and electronic circuit wiring screed earthing is provided in the panel, the same shall be highlighted in the bid.

All the metal parts shall be treated so as to ensure efficient anti-corrosive protection. Hardware shall be zinc-passivated or electro galvanized. Panel enclosure and structure and supports shall be thoroughly cleaned and degreased to remove scale and rust etc. External surface shall be prepared for final painting of shade specified in the bid document.

All panels shall be same height so as to form a uniform line-up to give aesthetic appearance.

All the control wiring shall be enclosed in plastic channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BS approved, PVC insulated, fire retardant, and copper conductor wire. 1.5 sq.mm size wire shall normally be used provided that the control fuse rating is 10 Amps and less and 2.5 sq. mm for control fuse rating above 16 A for electrical circuits and 1.5 sq. mm for electronic circuits.

All electronic modules and components shall be accessible from front of panel only. Modular plug-in/ draw out assemblies for both the system control electronic equipment and power electronic equipment’s shall be used.

Suitable removable type hooks shall be provided for lifting the panel.

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10.6.System Components

10.6.1.General Requirements

The panel shall include suitable isolating device i.e. circuit breaker, MCCB or switch fuse for main supply, contactors, diodes (Converters)/ IGBT (Inverter) modules with protective devices, reactors for suppressing commutating notches, control circuit, control accessories, indication and annunciation etc.

Main isolating device shall function as a manual disconnect and shall be an AC thermal magnetic circuit breaker or a fuse switch to trip automatically on fault currents. Interlock shall be provided between the doors, so that the door cannot be opened unless the breaker is open.

All power diodes shall be of silicon type with minimum VBO rating as 2.5 times the rated operating voltage.

The contactor shall be air brake type with required number of contacts for interlocking.

The fuses used for controller device protection shall be semiconductor types. Other fuses shall be HRC type mounted inside the panel. All the switches shall be rotary type and fitted on front of the panel.

All the electronic cards shall be modular for easy replacement. In case of thyristor application, test point shall be provided for testing the thyristor firing pulse in control circuit and the thyristor gate terminal.

Perspex type transparent insulating material shall be used for covering live components. Drive keypad shall be provided outside the panel.

10.6.2.Reliability Features

The expected life time of the VFD shall be 20 years. The VSD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

The controller design shall incorporate the following reliability features.

- a) Pre-tested components with power components to be 100% tested under dynamic conditions.

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- b) Printed circuit boards shall be computer tested and adjusted.
- c) Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- d) Printed circuit boards shall be treated for tropical, humid, dusty and corrosive environment.

10.6.3.Maintenance Features

The controller design shall incorporate the following maintenance features.

- a) Modular construction.
- b) Printed circuit boards shall be plug connected.
- c) All components shall be easily accessible from the front of the enclosure.
- d) Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

10.7.Control, Protection, Metering & Indication/ Annunciation

10.7.1.Operator Control Panel

The manufacturer shall provide all the necessary system control, protection; alarm equipment and metering for the entire drive system and its auxiliary equipment.

Automatic sequence control shall include start-up of cooling system, interlock checking, automatic start and run-up drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for Run/ Stop, Local/ Remote, Increase/ Decrease, Menu Navigation and Parameter Select/ Save. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or Standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for modification of all electrical values,

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configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics.

10.7.2.Protective Features

The system offered shall incorporate adequate protective features properly coordinated for the drive control and for motor but not limited to”

- a) Incoming line surge protection
- b) Under/ Over voltage protection
- c) Phase loss/ Phase reversal protection
- d) Programmable over current protection
- e) Inverter fault
- f) Over frequency operation
- g) DC line over voltage
- h) Ventilation loss
- i) Over temperature of equipment
- j) Over speed of motor
- k) Specific motor protection

10.7.3. Protective Alarms

The system offered shall incorporate protective alarms, required for various fault conditions for the drive motor, Supply cables, Converter transformer, DC reactor and the Converter. Alarms shall also be included for failure of various auxiliaries together with the identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

10.7.4.Control

The following controls shall be provided as a part of the Operator Control Panel or through separate selector switches.

- (a) Start/ Stop
- (b) Speed Control (Raise/Lower)
- (c) Forward/ Reverse
- (d) Auto/ Manual mode

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- (e) Local/ Remote
- (f) Emergency Stop
- (g) Start/ Stop by-pass starter
- (h) Trip Remote Breaker

10.7.5.Indications

The following indications shall be provided as a part of the Operator Control Panel.

- (a) Motor running
- (b) Motor stopped
- (c) Motor over speed
- (d) AC Mains ON
- (e) Rectifier output ON
- (f) Systems ready to start
- (g) Motor zero speed
- (h) Remote breaker tripped

10.7.6.Metering

Digital display of the following parameters shall be as a part of the Operate Control Panel selectable by the operator.

- (a) Input AC voltmeters
- (b) Input AC frequency meter
- (c) Input AC ammeter
- (d) Output Voltmeters
- (e) Output Ammeter
- (f) Output frequency
- (g) Motor terminal state
- (h) Drive thermal state
- (i) Motor speed
- (j) Motor energy meter
- (k) DC volts

Provision for remote metering shall be provided. Associated transducers shall be included for that purpose.

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10.7.7. Annunciation

Potential free contacts shall be provided for following annunciations and shall be wired up to terminal block for Client's use for remote monitoring.

- (a) Rectifier fuse failure
- (b) Main AC failure
- (c) Inverter fuse failure
- (d) Inverter overload
- (e) Inverter high temperature
- (f) Failure of panel cooling system
- (g) Motor failed to start.

10.8. INPUT/OUTPUT

Typical Input/output of VSD Shall be as below Table:

Basic I/O Data	
Control signal inputs: Analogue (differential), 4 channels	
Analogue voltage/current Max. input voltage Input impedance Resolution Hardware accuracy Non-linearity	0-±10 V/0-20 mA via switch +30 V 20 kΩ (voltage) 250 Ω (current) 11 bits + sign 0.5 % type + 1 ½ LSB fsd 1½ LSB
Digital: 8 channels	
Input voltage Max. input voltage Input impedance Signal delay	High>9 VDC Low<4 VDC +30 VDC <3.3 VDC: 4.7 kΩ , ≥3.3 VDC: 3.6 kΩ ≤8 ms
Control signal outputs: Analogue, 2 channels	
Output voltage/current Max. output voltage Short-circuit current (∞) Output impedance Resolution Maximum load impedance for current Hardware accuracy Offset Non-linearity	0-10 V/0-20 mA via software setting +15 V @5 mA cont. +15 mA (voltage) +140 mA (current) 10 Ω (voltage) 10 bit 500 Ω 1.9 % type fsd (voltage), 2.4 % type fsd (current) 3 LSB 2 LSB
Digital, 2 channels	

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Basic I/O Data	
Output voltage Short-circuit current(∞)	High>20 VDC @50 mA, >23 VDC open Low<1 VDC @50 mA 100 mA max (together with +24 VDC)
Relays, 3 pcs	
Contacts	0.1 – 2 A/U _{max} 250 VAC or 42 VDC
Reference voltages	
+10VDC -10VDC +24VDC	+10 VDC @10 mA short-circuit current +30 mA max -10 VDC @10 mA +24 VDC short-circuit current +100 mA max (together with Digital Outputs)

11.Soft Starter

This specification describes the requirements for a solid-state torque-controlled starter (Controller) used to provide linear ramp starting and stopping of three-phase AC induction motors. The requirement is for a stand-alone unit that negates the need for further equipment in terms of protection, viewing and controlling.

11.1.Quality of the product and of the Supplier

The soft- starter shall be developed and qualified in accordance with international standards, particularly with the standard dedicated to soft-starter EN / IEC 60947-4-2. The starter must be CE marked under the harmonized standard EN / IEC 60947-4-2. In accordance to electromagnetic compatibility, the soft-starter must comply with Class A for conducted and radiated emissions, described in the standard EN / IEC 60947-4-2, and this for all the basic functions available within the soft-starter. Class B can be obtained with additional accessories and covers only soft-starters with a rated current not exceeding 170 A.

The Soft-starter shall comply UL 508 and CSA "Industrial Control Equipment

The manufacturing facilities for Soft-starters and associated activities such as development and design must be certified ISO 9001 version 2000 and ISO 14001

11.2.Description of the product

The operating principle of the Soft-starter should not simply take ground on a limitation of motor current during the transitional phases or on a voltage ramp but on

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a torque control motor. The Soft-starter should provide a torque ramp during the acceleration phase. Thus, it can control the torque during the starting period and if necessary, provide a motor torque constant throughout the acceleration phase.

For pumping applications, the deceleration will be on torque a ramp.

All Soft-starter sizes will have the same control Pc boards. That control board must be identical for all applications, so the same Soft-starter can be used on a grinder, a pump or a conveyor (taking into account the sizing).

All Soft-starters shall be equipped with means for measuring current motor current to ensure engine protection.

The terminals for the mains should be located top of the Soft-starter and the motor terminals will be bottom (through wiring).

All Soft-starter sizes must have terminals for the connection of the by-pass contactor.

The measurements of the current will be active when the Soft-starter is by-passed.

The Soft-starter should have a separate power control.

The terminals of the board control shall be of plug type.

11.3.Environment

The Soft-starter shall be able to operate in ambient temperatures from -10 to + 40 ° C without derating and between 40 and 60 ° C with derating of 2% per degree C above 40 ° C.

The maximum relative humidity will be 95% without condensation or dripping water according to standards IEC60947-4-2.

The storage temperature can be between -25 ° C to + 70 °

The maximum operating altitude is 1000 meters (3280 feet), beyond, the Soft-starter will be downgraded from 2.2% per 100 meters.

The supplier will indicate a noise level of the Soft-starter, this noise level should not exceed 70 dBA.

About the Soft-starter cooling, if the Soft-starters are equipped with fans, those fans should not run continuously. They will be managed automatically according to the temperature of the radiator.

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The degree of environmental pollution will be a maximum degree 3 according to IEC 60664-1 (or IEC 60947-4-2).

The supplier will indicate the connection diagrams of the Soft-starters.

The supplier will make available the association charts between circuit breakers, fuses, contactors and Soft-starters in a way to ensure coordination of type 1 or type 2.

11.4.Electrical characteristics of the Soft-starter

The run category of the Soft-starters will be on a standard AC 53a following EN / IEC 60947-4-2.

The supplier shall be able to offer Soft-starters in one or several ranges in a way to cover mains from 208 to 690V. (208 to 690 V -15% +10%).

The current range of Soft-starters will be between 17 and 1200 A.

The Soft-starter will automatically adapt to the frequency of the mains 50 or 60 Hz with a tolerance of + / -5%. Through configuration, it will be capable of operating at a frequency network which may vary + / - 20%.

Logic inputs: the Soft-starter should have at least 4 isolated digital inputs 24V.

Outputs: the Soft-starter must have at least 3 relays with a close contact

Maximum switching capacity on inductive load: 1.8 A at 230 Vac and 30 Vdc.

Minimum switching capacity 10 mA at 6 Vdc.

Outputs: the Soft-starter must have at least 2 digital outputs 24V

Analog outputs: the Soft-starter will have One analog output signal with a 0 - 20 mA or 4 - 20 mA. This signal may be scaled.

The starter shall have its own source power supply (24V) for logic inputs/outputs

The supplier will offer an array of choices of Soft-starters for 2 types of design:

- Sizing 1:

Starting from cold state (motor service S1): 1 start at 3 In for 46 seconds.

On an operating level (motor service S4), with a duty cycle of 50% and 10 starts per hour or equivalent thermal cycle: 1 to 3 In startup for 23 seconds

-Sizing2:

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Starting from a cold state (motor service S1): 1 start at 4 In for 48 seconds

On an operating level (motor service S4), with a duty cycle of 50% and 5 starts per hour, or equivalent thermally cycle: 1 start at 4 In for 25 seconds.

11.5. Protections

The starter will include the management of PTC sensors.

The starter will calculate continuously the motor overheating from the real current value (the current must be measured and not estimated). Several classes of thermal protection will be proposed following the standard EN/IEC60947-4-2: Classes 10A, 10, 20, 30 and the intermediate classes, (one less than the 10A class, a class between 10 and 20 and between Groups 20 and 30). The calculation of the thermal protection must be active even when the Soft-starter is not power energized.

The starter shall be protected against thermal overload.

The Soft-starter will detect an under- load from the motor torque information. The detection threshold and the allowed duration of the under- load shall be adjustable. That protection may result in a default on the Soft-starter or simply cause an indication in the form of an alarm on a logic output.

The Soft-starter will detect an over- load from the information of the motor current. The detection threshold and the allowed duration of the over-load shall be adjustable. The duration of overload may be adjustable from 0.1 seconds. That protection may result in a default on the starter or simply cause an indication in the form of alarm on a logic output.

The Soft-starter shall have protection against reverse-phase network, the loss of phase (s) on mains or on motor.

The Soft-starter will take into account the management of an external fault. When the contact is open, the Soft starter trips in fault.

The protections should be maintained even when the Soft-starter is by-passed by a contactor

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11.6.Communication

The starter will include a multipoint serial link to be connected directly to a Modbus bus.

The starter shall be able to be connected to Ethernet and other networks and communication bus option.

The communication shall provide access to the control, adjustment and monitoring of the Soft-starter.

11.7.Main functions

The starter may start and stop several motors in cascade.

A second set of motor parameters can be switched by a logic input.

To protect the motor during long standstill periods against condensation, the Soft-starter shall have a function of pre-heating without causing rotation of the motor. The current pre-heating system must be adjustable.

The Soft-starter will handle the by-pass of the Soft-starter: manage the closure of the by-pass at end of acceleration time and open that by-pass at end of stop sequence. That function must be compatible with the types of judgments: freewheel, breaking control

The Soft-starter may control the line contactor. The contactor will be closed from a run control and open at end of shutdown of the motor.

The access to the settings can be locked by code. The monitoring parameters should remain accessible.

11.8.Monitoring

The starter shall have a basic screen dialogue and programming push-buttons. An optional kit to get remote terminal will be offered.

The following information must be accessible on the screen dialog

- Motor current
- Torque
- Motor thermal state
- Cos φ

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- Active Power.
- Current status (acceleration, deceleration, ...).
- Operating time.
- The last fault occurred.

The following information will be available on the analog output.

Motor current.

Torque

Motor thermal state

Cos φ

Active power.

The Soft-starter has in option advanced dialogue solutions such as:
software workshop for PC to prepare, store, download and print settings.
console display with clear parameters.

11.9.Motor Data

The starter must be sized for use with IEC motors or NEMA motors with the following data: Power ____kW or ____HP Power (horsepower) ____ A permanent current amp rated at ____ volts.

12.INSPECTION, TESTING AND ACCEPTANCE

Inspection and testing shall be carried out based on latest revision of ITP and approved vendor drawings certified for construction. In case of any ambiguity between vendor drawings and ITP, the requirement indicated in technical specification shall govern.

13.DOCUMENTATION

13.1.Information To Be Supplied With Tender

Statement of compliance with the requisition or any deviations shall be listed complete with technical implications.

Any items requiring further clarification or discussion complete with the VENDOR's recommendations and alternatives.

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Manufacturer shall state the place of manufacture of the equipment and nearest service facilities for the site location.

Complete technical description of the equipment including the relevant drawings and diagrams.

13.2.Calculation & Drawings

- (a) Overall dimensions
- (b) Front of panel layout
- (c) Schematic drawings showing Power Circuits, Control Circuits, Alarm Circuits, Power Semiconductors, Printed Circuit Boards, Relays, Transformers, Inductors, Contactors etc.
- (d) Connection diagrams showing Cable Termination Details, Load, Control Signals and Earthing.
- (e) Protective Device Characteristics shall be scheduled, stating characteristics all protection.
- (f) Harmonic Calculation

13.3.Installation & Operating Manual

The VFD VENDOR shall provide a comprehensive installation and operating manual, detailing the operation, maintenance and fault-finding procedure for the complete equipment.

14.VENDOR RESPONSIBILITY & GUARANTEE

The supplier shall replace any damaged equipment resulting from poor workmanship and/or faulty design. The supplier shall also replace any equipment failed under the following conditions:

- 1) Failure under start-up and commissioning tests according to IEC recommendation.
- 2) The supplier of the equipment under this specification shall guarantee the equipment and shall replace any damaged equipment/parts resulting from poor workmanship and/or faulty design.
- 3) The supplier shall replace any equipment/part failed under the following condition:

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- 4) - Failure under startup and commissioning tests performed according to IEC recommendations.
- 5) Satisfactory and trouble-free operation of equipment under specified conditions generally shall be guaranteed for a period of 12 months from starting to operation.
- 6) The supplier shall guarantee to support any spare parts for a period of 10 years.