REVISION HISTORY SHEET

REV. NO.	DATE	NATURE OF CHANGE	REASONS	PREPARED BY	APPROVED BY
00	09-11-2020	FIRST ISSUE	------		

TECHNICAL SPECIFICATION OF IGBT BASED VFD FOR SQUIRREL CAGE INDUCTION MOTOR FOR BOILER FEED PUMP (BFP)

1. Project Details

Sl. No.	Parameter	Specification
1	Project Location	JHAGADIA, BHARUCH, GUJARAT, INDIA
2	PROJECT	1 x 120 MW COAL BASED REHEAT TPP
3	CUSTOMER	DCM SHRIRAM LTD.
4	CONSULTANT	DEVELOPMENT CONSULTATIONS PVT. LTD. (DCPL)

2. Environment Specifications

Sl. No.	Parameter	Specification
1	Maximum Ambient Temperature	50 °C
2	Minimum Ambient Temperature	12°C
3	Equipment Design Temperature (IS-9676)	50°C
4	Relative Humidity	95%
5	Altitude	Less than 1000 M above MSL
6	Seismic Zone	Zone III as per IS : 1893 Part-1
8	Environment	Polluted and Corrosive
9	Location of VFD panels	Indoor, Air conditioned room

3. Input and Transformer Data

Sl. No.	Parameter	Specification
1	System Voltage / Frequency /Ph	11kV / 50Hz / 3
2	Voltage Variation	+/-10%
3	Frequency Variation	+/- 5%
4	Combined Voltage and Frequency Variation	+10%
5	Fault Level	50KA for 1 sec
6	Transformer Type	Dry type integrated Transformer (In Vendor scope)
7	Rating	Transformer must be designed to carry 110% current of calculated VFD rating. Transformer sizing calculation shall be provided along with offer.
8	Power Cables	Cable termination to be provided by the vendor for Transformer HV side cable termination suitable for 1Rx3Cx300 sqmm, 11kV, Al, XLPE cable. The exact sizes will be intimated during drawing approval stage. Cables, glands and termination kits in Customer /BHEL scope.

4. Motor Data

Sl. No.	Parameter	Specification
1	Type	Squirrel Cage Induction Motor
2	Scope	Manufactured by BHEL-Bhopal
3	Rated Output	2200 kW, 2990 RPM
4	Rated Voltage and Current	11 kV, 133 A
5	No load current	34 A
6	Fed from	Variable Frequency Drive (V/f Control) with Bypass
7	Duty Class	Continuous - S1
8	Efficiency and Power Factor:	

% of Load	Efficiency	Rated PF
50	94.5	0.91
75	95.5	
100	95.8	

Sl. No.	Parameter	Specification
9	Power Cables	Cable termination to be provided by the vendor for VFD Output side cable termination suitable for 1Rx3Cx300 sqmm, 11kV, Al, XLPE cable. The exact sizes will be intimated during drawing approval stage. Cables, glands and termination kits in Customer /BHEL scope.

5. Scope:

Sl. No.	Scope of Supply	Description
1	a) Fully Assembled Units of 11kV VFD Panels (IGBT/SGCT/IGCT), Air Cooled with integrated Dry type transformer. b) All interconnecting cables between the VFD and integrated Transformer. c) Local Control Station (LCS) mounted near motor (in safe area) for each VFD. d) VFD Output Isolator (Motorised) . e) Cable glands and lugs for LCS (Weather proof). f) Any special cable other than power and control cables from VFD to other equipment. g) Any special tools and tackles h) Laptop (1 No.)	The vendor shall be responsible for engineering and functioning of the complete VFD system, meeting the intent and requirement of this specification & Customer specification. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, adequacy of motor cable size selected by BHEL etc. All necessary interlocks as required for safe and reliable operation of VFD system along with Input breaker, Output Isolator and Bypass breaker shall be provided in VFD system. If any special arrangement is required in Input breaker and output isolator, same shall be informed by the vendor in the offer. The machine shall normally run on VFD. In case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended independently. All other control and protections not included in owner's scope but required for vendors supplied system shall be in vendor's scope.

6. VFD Specifications

Sl. No	Parameter	Specification
1	Drive	VFD for BFP
2	Input Voltage	From Integrated dry type Transformer
3	Power/Torque vs Speed	Torque α Speed^2 , Power α Speed^3
4	Single Line Diagram	See Attachment 3-661-00-00978
5	Output Voltage of VFD	0 to 11kV (V/F = Constant)
6	Output Current of VFD	133 Amps at 50°C (Design Ambient)
7	Output Frequency	0 to 50Hz , Resolution: +/- 0.01% under transient conditions; +/- 0.5% under steady state conditions
8	Overload capacity	115% of rated current for 1 minute at rated voltage
9	Speed Regulation & Speed Accuracy	As per attached Customer Specification
10	Drive Control	Sensorless Vector Control
11	Braking Operation	Not Applicable
12	Output LC Sinusoidal Filter	Motor is designed for PWM operation. Distance between VFD and Motor is ~200 meters. Vendor to clarify and offer output Filter, if required.
13	VFD Panel Construction	a) Protection Class: IP42 b) Panel: Free standing, floor mounting type, comprising of rigid welded structural frames with Cold Rolled Sheet Steel enclosure of minimum thickness 2 mm for load bearing and 1.6 mm for other members. All doors and removable covers shall have neoprene gaskets. Ventilating louvers shall have easily removable and washable dust filters. c) Cooling: Forced Air Cooled VFD should be considered. Cooling system shall include well dimensioned panel, adequate cooling air flow path. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. Vendor to provide low noise redundant cooling fan for the VFD panels. The fans shall have 100% redundancy with provision for autostart of standby fan as per attached Customer Specification. Changeover scheme shall be submitted along with the offer. Suitable thermal switch for exit air temperature monitoring shall also be incorporated. d) Earth Bus – minimum 50*6 mm Copper.

Sl.	Parameter	Specification
13	VFD Panel Construction	e) Busbar Material – Electrolytic grade Copper, colour coded. Sleeving/shrouding for safety purposes shall be done. f) Door Interlock: The VFD shall have a door interlock for safety. This interlock system should ensure that none of the power cabinets can be opened until the main source of power is disconnected or will cause the main source of power to trip. Additionally the same interlock system should ensure that power cannot be initialized to the drive unless the doors are closed. Suitable shrouding mechanism shall be provided so that the DC capacitors cannot be touched till their voltage is zero. g) Painting: 2 Coats of Primer and 2 Coats of Finish Paint to be given for all surfaces of enclosure. Paint shall be Epoxy Based with Powder Coated Finish – Battle ship grey IS:632 as per IS-5. Paint Thickness: 60 Microns (minimum). Exact paint shade will be confirmed during drawing approval stage. h) Power and Control Wiring shall be done with Fire retardant (FRLS) cables. i) Height of the terminal from cable gland plate shall be adequate to take care of the cable sizes and quantity mentioned. Minimum space for the power cable termination shall be 600mm clear from the cable gland plate. Cable entry will be from bottom only. Gland Plates shall be blank (undrilled) – to be drilled at site. Gland Plates shall be minimum 4 mm thick Aluminium (steel not allowed). Gland plate shall be of sufficient strength to handle all the cables. j) All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipment and power electronic equipments shall be used. k) All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment. l) Lugs for all control cables shall be terminated in terminal block itself. This would avoid usage of different types of lugs at site during commissioning. m) 20% spare terminals shall be provided.
14	Noise Level	Shall be less than 85dB at a distance of 1 metre from the outline of VFD Panels at a height of 1.8 metres from the floor with all the fans running in the VFD Panels.

Sl. No.	Parameter	Specification
15	Storage Temperature	-40°C to +60 °C
16	Vibration	According to IEC68-2-6
17	Interference	According to IEC801 parts 2,3,4 Immunity: The panels shall be designed so as to have low Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI).
18	VFD Efficiency	Shall be min 95%. Exact value to be specified by the Vendor.
19	Duty Cycle	Class I Duty Cycle as per IEC 146-1
20	VFD Requirements	a) Input Choke: Input chokes to be provided, if necessary. b) Local/Remote: Selector switch shall be provided for operator to select type of operation: Local – Operation from VFD Panel for Speed Control from door mounted interface; Remote – Operation from DCS/LCS. If VFD is set for speed reference from Remote, it shall be possible to program the VFD to either shutdown, go to minimum speed or continue operation at its last known speed reference point whenever a loss of speed reference is detected. c) Local Start/Stop Push Button to be provided either on Panel door or on keypad. d) Door Mounted Lockable Push-Button with cover to be provided with 2NO + 2 NC contact for Emergency Stop. One normally open and close contact to be wired to Terminal Block for external Interlocking / Annunciation. e) Every Panel shall be provided with CFL illumination Lamp with limit switch and MCB. Space heater shall be provided in panel with switch fuse and variable setting thermostat. 240V power socket with MCB shall be provided.

Sl. No.	Parameter	Specification
20	VFD Requirements	f) 230V, 1phase, 50Hz (exact rating during drawing approval stage) Power Supply to the motor space heater shall be derived from VFD. Necessary interlocking arrangement for this supply shall also be made available in the VFD panels. g) Vendor to clearly mention the dimension of VFD and Isolator Panel alongwith panel clearances in the technical offer. h) PLC: PLC shall be provided for Interlocking and Protection (if required) i) The expected life time of the drive system shall be minimum 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years. j) Any special requirement regarding CT/ PT, protection relay or any other device, in input breaker, which is required for functioning of VFD system shall be considered by the VFD vendor in their scope.
21	VFD Features	a) Soft Start and Auto Restart b) Auto Speed Search Facility (Catch on Fly) shall be available for starting into rotating loads. c) Power loss ride through (Kinetic Buffering) and for voltage dips over 20% or Power interruption for less than 2 secs. d) Automatic VFD tuning during start-up. e) Flux optimisation function shall be provided to reduce the total energy consumption and noise level in case drive is operated below nominal load. f) Selectable reverse run prohibition g) Adjustable motor overload feature h) Settable minimum and maximum operating frequency i) VFD shall produce not greater than 1% torque pulsation to the shaft of driven equipment. j) Field adjustable Torque limits and acceleration and deceleration ramps k) Accelerate / Decelerate Times to be specified. l) Four (4) user programmable preset speeds. m) Earthing scheme should be provided by the vendor.

Sl.	Parameter	Specification
21	VFD Features	n) The equipment may be stored outdoors for long periods before installation. The packing should also be suitable for outdoor storage areas with heavy rains / high ambient temperatures. o) Vendor shall certify readiness of system fit for commissioning. Vendor's scope shall also include supply of all specialized tools and tackles required. p) VFDs shall be installed in Air-conditioned area but it shall be suitable for operation in non-air-conditioned area also. q) Any special cable other than power and control cables required to connect VFD to other equipment shall be in vendor scope. r) All electronic PCBs/Modules must have conformal coating to take care of site conditions.
22	Controls and monitoring	a) VFD shall be with an interactive and user-friendly door mounted digital operator interface with LCD display and sealed membrane type keypad. b) The operator interface shall be used for drive programming, drive monitoring and drive trouble shooting. The operator interface must also be able to start and stop the drive, reset VFD faults and manually adjust the VFD's speed reference. c) The operator interface shall have LED indicators for drive fault, drive run, and drive in current limit. d) The operator interface shall allow monitoring of inverter operating conditions including speed, current, voltage, torque, power etc. e) Messages shall be alphanumeric in nature. All the fault messages shall be in English. f) Provision shall be made available for remote operation. g) The operator interface shall be able to display all real time operating variables and all drive programming parameters. h) The operator interface shall be capable of displaying a specific user selected parameter on power-up. This power-up parameter would typically be a parameter that is important to the operator such as motor speed or motor load i) The following Control signals must be provided: 1) Local/Remote 2) Emergency stop 3) Trip/Close Input breaker

Sl. No.	Parameter	Specification
22	Controls and monitoring	These are indicative. Vendor to suggest the interlocking scheme using these and other outputs as required for the system during detailed Engineering. These Outputs shall be provided with individual relay having 3 changeover potential free contacts wired to terminal blocks. j) All VFD operating parameter shall be stored in nonvolatile memory. k) The drive shall have built in monitoring of following parameters as minimum on its digital operator interface and these parameter shall also be displayed at Plant DCS through Modbus link: i) Input & Output Frequency ii) Input & Output Current iii) Motor Speed iv) Input & Output Voltage v) DC Bus Voltage vi) Input & Output Power vii) Digital Input Status viii) Digital Output Status ix) Analog Input x) Drive Thermal state xi) Motor energy meter xii) Hour run xiii) Transformer Temperature for alarm & trip l) Necessary transducer shall be provided with 4-20mA output for indicating Motor Speed and Motor Current in the DCS. Transducers shall be capable of driving 500 ohms load. m) The following indications shall be provided on the VFD Panel Door/ Keypad: i) Motor Running/ VFD ON ii) Motor Stopped/Tripped iii) AC Mains ON iv) Auxiliary Control Supply ON v) VFD Ready vi) VFD Fault vii) External Fault viii) Emergency Stop Activated ix) Motor Overspeed x) Input Breaker Trip xi) Motor zero speed xii) Rectifier output 'ON' xiii) Transformer winding temperature alarm & trip. n) The VFD shall store fault logs of minimum last 10 faults in memory.

Sl. No.	Parameter	Specification
22	Controls and Monitoring	o) The interface details of VFD shall be incorporated as required for data communication with DCS system with serial interfaces with RS485 data links. Necessary hardware shall be included in the scope and the interface protocol (i.e. Modbus only) shall be provided. The following Audio-visual annunciations must be provided. 1) Rectifier fuse failure / drive fault 2) Main AC failure 3) Inverter fuse failure / Drive fault 4) Inverter overload 5) Inverter high temperature / Drive fault 6) Cooling system failure 7) Motor failed to start / Drive fault 8) Transformer fault and alarm 9) Communication and measurement system unhealthy
23	Protection	Following protections shall be built in within the inverter and any other protection as required: a) Motor Overload / Over Torque b) Instantaneous Over current (This device shall monitor the peak output current continuously and shall provide instantaneous shutdown without component failure whenever its trip point is surpassed. The trip point must be greater than or equal to 110% of the VFD's rated full load output current) c) Ground Fault Protection – 5-10A within 300ms maximum. d) Over Voltage/Under Voltage - VFD shall be able to withstand >20% dip in supply voltage for 2 secs without damage to semiconductors or fuses. e) Output Short Circuit f) Output Phase Loss/Fuse Failure g) Phase Sequence Protection h) Input Phase Loss/Single Phasing Preventer i) Over Speed/Over frequency of motor j) Heat sink over temperature/VFD Panel Temperature High Stall prevention (During acceleration, deceleration and constant speed operation)

Sl. No.	Parameter	Specification
23	Protection	k) Loss of Cooling Fans l) External faults like Transformer Fault and Alarm m) Incoming Line surge protection n) Under/Over voltage protection o) Inverter fault p) System earth fault protection q) The system shall be designed to deliver the moto input current and torque for the complete spee torque characteristics of the driven equipment. r) If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than 1 min, the drive shall shut down to prevent over heating of the motor and damage to the drive. s) The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds. t) 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 shut down of the system shall be available for a period of minimum 4 days after a shut down even though no supply available.

Sl. No	Parameter	Specification
24	**Dry type Transformer (Mounted in panel)**	Dry type Transformer a) HV voltage: 11kV with Taps of ±5% in steps of 2.5% b) LV voltage: Multi secondary type. Number of secondaries and secondary voltage to be indicated by the vendor in technical offer. c) Class of insulation: Class F or higher d) Winding material : Electrolytic grade Copper Protection: RTDs (2 nos) to be provided in each limb for winding temperature measurement. Temperature scanner to be provided for winding temperature measurement of all limbs. Alarm and trip contacts required for annunciation for fault and tripping action. Construction: The dry type transformer shall be mounted in a panel which will be mounted along with the VFD panel Connection: HV Incomer: Termination arrangement to be provided for 1Rx3Cx300sqmm, 11kV, Al, XLPE Cable. The exact number and sizes will be intimated during drawing approval stage. Cables in BHEL/Customer scope. LV Connection: Cable between LV secondaries and VFD to be supplied by the Vendor. This shall be used for testing of the VFD and later bunched in the panel during dispatch and the same shall be connected at site. Necessary connection and routing arrangements to be made by vendor.

Sl.	Parameter	Specification
25	**Isolator Panel**	VFD Vendor to supply Isolator Panel (Motorised) for connection at the VFD output and shall be suitable for variable frequency operation. The selection of Motorised Isolator Panel shall be governed by VFD manufacturer's operational requirements. Adequate provision shall be provided for closing from remote through contacts and from local by switch provided on panel door. a) Rated Voltage = 11 kV b) Rated Current = Shall be designed to carry 110% of VFD output Current. Isolator shall be suitable for overload requirements of the VFD. c) Rated short time current rating for terminals = 50kA for 1 Sec d) Termination shall be suitable for termination of 11kV, 03C x 300 Sq. mm, 11kV, Al, Cable at the input and output of the Isolator Panel. Provision shall be kept for O/P cable termination from Bypass breaker output as well as cable connection to motor. e) Aux. supply = 110V 1 ph UPS supply will be provided by customer. Feeder rating to be confirmed by vendor. f) Sheet Steel thickness = 2mm for doors and covers and 3mm for load bearing members and instrument panel (if any). g) Degree of Protection = IP42 h) Paint shade & thickness : Shade Battle ship grey IS:632 as per IS-5., Thickness: 60 Microns (min). i) Busbars = Electrolytic grade Tinned Copper j) ON/OFF indications shall be provided on panel door. All indicators shall be LED type. k) All components shall be accessible from front side for easy maintenance. l) Panel space heater shall be provided with Thermostat.

Sl.	Parameter	Specification
25	**Isolator Panel**	m) Facility for padlocking of panel doors shall be provided. n) Provision shall be provided for charging of spring charging motor manually. o) Suitable rating Surge Arrestors shall be used for Isolator. p) Safety interlocks shall be provided in the panel so that, panel cannot be opened when current is flowing in this circuit. q) Sub vendor: Isolator shall be sourced from reputed approved sub vendor of VFD manufacturer.
26	**Local Control Station (Weather proof) Features**	a) The enclosure shall be made of cast light metal Alloy. b) Degree of protection is IP55.LCS shall be provided with integral canopy.The canopy shall be made of atleast 2mm galvanized sheet steel or FRP.The canopy shall be suitable for providing protection against rain from top and two sides. c) The LCS shall be provided with gaskets made of non-inflammable and self-extinguishing material. d) Paint shade is Shade Battle ship grey IS:632 as per IS-5. Paint shade will be confirmed during drawing approval stage. e) A warning inscription “Isolate power supply elsewhere before opening” shall be provided on the panel. The warning inscription shall be embossed on the enclosure or a separate warning plate fixed to the enclosure with screws. The warning plate shall be nickel plated brass or stainless steel. f) The LCS shall be provided with two earthing studs with lugs on external surface of enclosures suitable for termination of 8 SWG GI wire. g) The Emergency Stop push button shall be mushroom type with stay put feature and lockable in pressed position. h) Sub vendor: LCS shall be sourced from reputed approved sub vendor of VFD manufacturer.

Sl.	Parameter	Specification
26	**Local Control Station (Weather proof) Features**	i) All control switches shall be provided with a pistol grip handle. j) Meters shall be suitable for the appropriate input and shall be calibrated for the actual parameters. Further, for Bypass operation, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. 1) 4-20mA Signals for Display from VFD: i. Actual Current (0-150A) ii. Actual Speed(0-3000rpm) 2) 0-1A signal for display of Bypass Current with suppressed scale 0-150A/900A k) Nickel plated brass cable glands (Weather proof) and tinned Copper lugs for cable termination shall be provided by the vendor. l) 230V Control supply to LCS shall be provided by customer.
27	Type of Control:	Completely programmable by the user as: a) Flux vector control with speed feedback b) Flux vector control without speed feedback c) Scalar V/F. VFD shall be capable of maintaining motor speed within ±0.5% without the use of a motor mounted encoder or tachometer. The drive shall have programmable V/F patterns along with user definable custom V/F patterns.
28	Harmonic Limitations – Source	Shall be as per latest IEEE 519 Voltage harmonics: Vendor to inform the values with calculations during detailed engineering stage. Current harmonics: Vendor to inform the source side 5^{th}, 7^{th} & 11^{th} harmonics values with calculations during detailed engineering stage. Vendor to supply harmonic filters, if required, to filter the harmonics generated by VFD at input/ supply side.
29	Harmonics at VFD Output / Motor Input	Shall be as per latest IEC 61800-4 Vendor to specify the maximum amount of voltage and current harmonics at the VFD Output / Motor Input terminals. It should not be more than 5%. If it is more than 5%, vendor has to provide output filter.

Sl.	Parameter	Specification
30	Switching frequency	To be specified by the vendor
31	Auxiliary Supply	a) 110V UPS feeder for VFD will be provided by Customer. KVA Rating is to be given by the Vendor. Power supply for electronic modules has to be derived from the UPS. b) 110V UPS feeder for Isolator panel will be provided by Customer. c) Auxiliary Supply – 415V, 3ϕ, 50Hz, 4 wire will be provided by customer. Feeder Power rating (short time & continuous) to be specified by the Vendor. d) Other supplies required by the VFD system to be generated internally within the VFD system. e) 230V AC non-UPS feeder for LCS shall be provided by Customer. Feeder Power rating to be specified by the Vendor.
32	Testing and Quality Plan	a) Routine Tests shall be carried out on all VFD and transformer panels as per relevant standards. b) Temperature rise test shall be conducted as Type test on one VFD along with Transformer. c) For other type tests, Type Test reports conducted earlier on similar type of equipment to be furnished for verification during detailed engineering. If valid type test certificates for transformer and VFD panels are not available as per DCM Specification, vendor shall conduct the type tests without any cost implication to BHEL. d) During fabrication, the drive and Transformer shall be subject to inspection by BHEL/ Customer, or by an agency authorized by the BHEL/ Customer to assess the progress of work, as well as to ascertain that only quality raw material is used.

Sl. No.	Parameter	Specification
33	Inspection, Training and Commissioning Support	a) Final Inspection: BHEL / Customer representative will be present at manufacturer's works for witnessing of final testing. This is to be incorporated in the Quality Plan. No charges shall be applicable for witnessing of final tests. b) Training: Training for 4 (Four) persons from BHEL / Customer for a period of 1 week at manufacturer's works/site free of cost. c) Commissioning: Commissioning of all VFD Systems at site shall be in the scope of Vendor. Final Acceptance shall be based on successful completion of the same. d) Any replacement of failed/damaged items during commissioning shall be exclusively at Vendor's cost. e) Vendor is advised to stock necessary spares and ensure easy availability to facilitate trouble free commissioning.
34	Laptop & Software for Computer Interface	Laptop shall be installed with Latest Compatible Licensed Operating System. The software must be loaded in the laptop & supplied along with interconnecting cables and accessories required for interface with the drive. The software should be an easy to use commissioning tool for drives and shall be provided along with the system. The interface details of VFD shall be incorporated as required for data communication with DCS system with serial interfaces with RS485 data links. Necessary hardware shall be included in the scope and the interface protocol shall be provided during detailed engineering.
35	Maintenance	The procedure for maintenance of VFD panels and the schedule thereof shall be mentioned in the offer.

36	Confirmations/Deviations to Specification	**Point-wise confirmation to this specification to be given along with offer**. Deviations, if any, shall be indicated separately. If there are no deviations to the specifications, supplier shall mention the same explicitly. A reply from vendor stating that "**Equipment will generally meet the specifications**" will not be accepted by BHEL. Clause-wise Confirmation / Clarifications of all Clauses in the Purchase Specifications 1 to 35 of Specification shall be furnished in the format below.

Point No.	Page No.	Confirmation / Clarification / Information / Deviation	Details	Remarks, if any

7. Consolidated Scope of Supply and Services

Sl. No.	Items	Quantity (Nos.)
1.	a) Fully Assembled Units of 11kV VFD Panels (IGBT/SGCT/IGCT), Air Cooled with integrated Dry type transformer	2 Nos.
	b) Weather proof Local control station	2 Nos.
	c) Isolator (Motorised) Panel	2 Nos.
2.	Laptop	1 No.
3.	Erection Supervision & Commissioning (Vendor to quote lumpsum commissioning charges for 12 days per drive which shall be considered for bid evaluation) Payment shall be made for actual mandays consumed at Site with per day charges calculated on the basis of the lumpsum charges quoted above. Lumpsum charges quoted shall include travelling, boarding and lodging expenses.	02 lots (lumpsum)

8. Documentation

Sl. No.	Parameter	Specification
1	Attached Documents	a) DCM SHRIRAM specification for VFD System b) Motor datasheet c) Single Line Diagram : 3-661-00-00978 d) Pre-Qualification Criteria of Medium Voltage Variable Frequency Drive (11 kV VFD) e) Datasheet for VFD system (Sheets 21 to 24)
2	Technical Information required along with Offer	a) Dimensional Drawing of Panels along with minimum clearance to be maintained for effective cooling, and Weight b) Technical Catalogue of VFD System being offered. c) Reference list for similar rating VFDs giving the following: Model number, Application, Rating, Year of supply and commissioning. Pre-Qualification Criteria of Medium Voltage Variable Frequency Drive (11 kV VFD) shall be used as qualifying criteria. d) Confirmation / Clarification / Information / Deviation List as per Point 36 above. e) Confirmation / Clarification / Deviation List to Specification and other documents in Sl No. (1) above. f) Design Calculation for VFD and Transformer sizing. g) Filled up Datasheet for VFD system.
3	Information / Confirmations required along with offer	a) Supply of the VFD shall be by OEM only. The name of the country from which the drive is sourced and the location of the manufacturing plant should be mentioned in the offer. b) After Sales Service and Support shall be given by the Vendor for a minimum period of 15 (fifteen) years after commissioning. Address of the Sales and Service Representatives in India with complete contact details: Name/Telephone/Email are to be provided. c) Vendor shall give a notice of at least 1 year to the end user of the equipment and BHEL before phasing out the product / spares to enable the end user for placement of order for spares and services.

4	Technical (unpriced) and Commercial (priced) Bids – For Evaluation	Refer sheet no. 18 of 24. Unpriced and Priced bids for Sl. Nos. 7(1), 7(2) & 7(3).
5	Information required for Customer / Consultant Approval (within 3 weeks from the date of Purchase Order)	a) Dimensional Drawing of Panels along with minimum clearance to be maintained for effective cooling, and Weight b) Schematic Diagram c) Bill of Materials for equipment to be supplied d) Feeder Requirements – UPS and 415V supply e) Losses at Rated Load (including Fans) f) Heat Loss for Air Conditioning System sizing g) Technical Catalogue of VFD System being offered h) Test Protocol and Quality Plan i) Type test certificates of similar or higher rating equipment j) Filled up Data sheet for VFD system
6	Information Required along with Supply. Maintenance Manuals and Documentation	a) Erection, Commissioning and Maintenance Manuals along with Final Drawings and Documentation – 2 Copies b) Test and Guarantee Certificates. c) Complete Bill of Material (item wise) for the equipment supplied. d) 1 no. CD ROM consisting of the above.

VFD SYSTEM DATA SHEET

A	**Environment Specifications**	
1	Maximum Ambient Temperature	50°C
2	Minimum Ambient Temperature	12°C
3	Equipment Design Temperature (IS-9676)	50°C
4	Relative Humidity	95%
5	Altitude	Less than 1000m above mean sea level
6	Location of VFD Panels	Indoor, Ventilated Room with Air Conditioning.
7	Seismic Zone	As per IS-1893-Zone-II
B	**Motor Data**	
1	Type	Squirrel Cage Induction Motor
2	Scope	Manufactured by BHEL-Bhopal
3	Rated Power (KW)	2200 KW
4	Rated Voltage and Current	11 KV & 133 A
5	Rated RPM	2990 RPM
6	Duty Class	Continuous - S1
C	**Input Power Supply Data**	
1	System Voltage / Frequency / Phase	11kV / 50Hz / 3
2	Voltage Variation	±10%
3	Frequency Variation	±5%
4	Combined Voltage and Frequency Variation	+10%
5	Fault Level	50kA for 1sec
D	**System Requirements**	
1	Drive application	BFP
2	Speed range required	As per application requirement
3	Speed Adjustment	Auto (from DCS) and Manual (From Drive)
4	Reference Signal	4-20 mA from DCS
5	Bypass Operation	Yes (Manual)
6	Synchronous Bypass	No
7	Input Breaker and Bypass Breaker	Yes (in BHEL Scope)
8	Fault diagnostic Required	Required
9	Cable distance between Input Breaker and VFD	30 meters (approx.)
10	Cable distance between VFD and Motor	200 meters (approx.)

11	Separate PE Conductor between VFD & Motor	(Vendor to Confirm)
12	Interface with DCS (Modbus)	Required
E	**VFD Data**	
1	Manufacturer	
2	Model No.	
3	Manufacturing Location	
4	Rating	
5	Applicable codes /standards	
6	Speed reference	4-20 mA from DCS
7	Speed range	
8	Switching Frequency	
9	No. of Pulse	
10	Total number of Diodes/ IGBTs/ IGCTs	
11	Drive output Voltage	11kV
12	Overload capability at 115% over current	60 Secs.
13	Inrush current 250% In for	
14	Combined efficiency (Transformer & Drive) at:	
	i) 100% Load	
	ii) 75% Load	
	iii) 50% Load	
	iii) 25% Load	
15	Overall power factor at:	
	i) 100% Load	
	ii) 75% Load	
	iii) 50% Load	
	iii) 25% Load	
16	Output voltage range and Accuracy	
17	Output Frequency range and Accuracy	
18	Type of Cooling	
19	Redundancy in Cooling	
21	Output Filter/ Choke:	
	i) Manufacturer	
	ii) Type/ Model No.	
	iii) Rated Current and Voltage	
22	VFD Panel Dimension	
	i) Length (mm)	
	ii) Height (mm)	
	iii) Depth (mm)	

	iv) Weight (kg)		
	(Dimensional details of all panels shall be furnished)		
23	a) Acceleration time		
	b) Deceleration time		
24	Degree of protection		
25	Paint Shade	As per BHEL Specification	
26	Heat Load (kW)		
27	Auxiliary Power Requirement:	415V, 3Ph, 4 wire	UPS supply
	i) KVA		
	ii) Voltage & Phase		
F	**Transformer Data**		
1	Manufacturer		
2	Manufacturing Location		
3	Type	Dry type integrated Transformer	
4	Duty	Continuous (Converter Duty)	
5	Rating (Transformer must be designed to carry 110% current of calculated VFD rating.)		
6	Class of insulation and temp rise		
7	Insulation level:		
	P. f withstand		
	i) HV Winding		
	ii) LV Winding		
	Impulse withstand		
	i) HV Winding		
	ii) LV Winding		
8	Fault Level on HV Side	50kA for 1 Sec	
9	HV Voltage and Phase	11kV and 3Ph.	
10	LV Voltage/ Current		
11	No. of LV Windings		
12	Rated Frequency	50Hz	
13	Impedance		
14	Cooling Type		
15	Winding Material	Electrolytic grade Copper	
16	Location of Tap Changer	HV Winding	
17	No. of Taps and Type		
18	Vector Group		
19	Neutral CT specification:		
	51G		
	64R		
	Vk		

	Im at Vk/2	
	RCT	
20	Cable Size/Type	
	i) HV Winding	
	ii) LV Winding	
21	No Load Loss	
	i) At 100% Voltage	
	ii) At 110% Voltage	
22	Full Load Copper loss at 75°C	
23	No Load Current	
	i) At 100% Voltage	
	ii) At 110% Voltage	
24	Efficiency at 75°C and unity power factor	
	i) At 100% of Full Load	
	ii) At 75% of Full Load	
	iii) At 50% of Full Load	
	iv) At 25% of Full Load	
25	Efficiency at 75°C and 0.8 power factor	
	i) At 100% of Full Load	
	ii) At 75% of Full Load	
	iii) At 50% of Full Load	
	iv) At 25% of Full Load	
26	Load at which maximum efficiency occurs	
27	Regulation at 75°C at full load	
	i) At 0.8 pf	
	ii) At UPF	
28	Dimensions	
	i) Length (mm)	
	ii) Height (mm)	
	iii) Depth (mm)	
	iv) Weight (kg)	
29	Degree of protection for enclosure.	
30	Paint Shade	
31	Heat Load (kW)	

ANNEXURE-I

HT & LT VARIABLE FREQUENCY DRIVE

Technical Requirements

1.00.00 GENERAL

1.01.00 CODES & STANDARDS

Transformer	IS:2026
Dry Transformer	IS:11171
Harmonics & EM compatibility	IEEE:519/IEC:61000/ IEC 61800-4
Contactor/ Switches/ Fuses etc.	IEC:60947, IS:13947

1.02.00 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear/ noise.

1.03.00 For the purpose of design of equipment/systems, an ambient temperature of 50˚C and relative humidity of 95% shall be considered. The VFD panels shall be located in an air conditioned room. However, equipment shall be suitable for operation even during failure of air−condition.

1.04.00 All equipment shall be suitable for rated frequency of 50Hz with a variation of ± 5% and 10% combined variation of voltage and frequency unless specifically brought out in the specification.

1.05.00 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment

i) Variable torque changing as a function of speed i.e. speed squared

ii) Constant torque over a specific speed range

iii) Constant power over a specific speed range where the torque decreases when speed increases

1.06.00 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field be separately programmable from 0.1 to 20 seconds.

1.07.00 Each channel and motor rating shall be rated to meet driven equipment requirements. The system shall be designed for linear continuous speed control from 60% to 80% of motor Critical speed and shall be of a modern proven design and fully compatible with excitation system offered.

1.08.00 The Total Harmonic Distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800-4 and it shall be considered in the design of the motor.

1.09.00 The overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 115% of rated current for one minute for variable torque application at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If the load demand exceeds the current limit for more than one (1) minute, the drive shall shut down to prevent overheating of the motor and damage to the drive.

1.10.00 During operation, the system shall be capable of developing sufficient torque under all load condition to respond to a 20% alteration in speed set point within a time limit up to 60 seconds.

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

1.12.00 The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 second.

1.13.00 Maximum noise level from the drive at one (1) meter distance, under rated load with all normal cooling fans operating shall not exceed 85dBA.

1.14.00 The drive system shall ensure following:

a) Harmful VFD induced harmonics which can create motor heating are eliminated.

b) VFD induced torque pulsation are limited to maximum 1% (even at low speed) so there is minimal stress to the equipment

c) Motor is protected from dv/dt stresses.

d) No appreciable increase in motor audible noise.

1.15.00 Paint shade shall be as per owner's guideline.

1.16.00 Contractor shall provide fully compatible electrical system, equipment, accessories and services.

1.17.00 All the equipment, material and systems shall, in general, conform to the latest edition of relevant National and International Codes & Standards, especially the Indian Statutory Regulations. Electrical performance of the system shall comply to IEEE, IEC and equivalent international standard.

2.00.00 TYPE

The Variable frequency drive (VFD) system shall be of a modern proven design for similar applications in power plants/industry. The system shall be of Voltage Source Inverter (VSI) type with minimum Twelve (12) pulse design. One spare VFD panel similar in all respect to other VFD panels to be provided and erected for each unit. In case of major failure in any of the VFD panels, Power & Control Cables shall be removed from the defective VFD panel and connected to the spare VFD panel.

3.00.00 OPERATIONAL REQUIREMENTS

General requirements of VFD system shall conform to IEC: 61800-2. The system shall be suitable for linear continuous speed control for a range indicated elsewhere as per the requirement of driven equipment. The system shall have necessary input and output devices to meet the requirements of IEEE 519 & IEC-61000 for the harmonics generated at the input of VFD panels and transferred to power supply bus. All required protections like Over load, earth fault, Over voltage, Over speed, negative sequence, load loss, output short circuit, input transient protection etc. as required and applicable for the system shall be provided.

4.00.00 DESIGN AND CONSTRUCTION FEATURES

System shall include the following equipment for each drive.

a) Power/control panels consisting of line converters, load converters and control system for drive control & protection.

b) VFD transformer on the source side, if required.

c) Breaker/Contactor on the motor side.

d) DC air core reactor or capacitor as per the system requirement.

e) Motor suitable for VFD application

f) LT power & control cables/cabling as required inside the VFD panels.

4.01.00 VFD TRANSFORMER, (if applicable)

1) TYPE

Indoor natural air-cooled dry type and shall be suitable for rating complying with system details.

2) RATING

The Transformers shall be sized so as to have 10% margin at design ambient conditions after considering final load requirements at peak conditions.

4.02.00 BREAKER/ CONTACTOR

1) TYPE

Shall be SF6 or vacuum type or air-break (for LT system) restrike free, stored energy operated and with electrical anti-pumping features.

These shall be electrically operated, mechanically latched type & shall have protection against over load, all AC/DC transients and voltage surges etc. Electronic control module shall be electrically isolated from these power switching devices.

2) TEMPERATURE RISE

Temperature rise of bus bars shall not exceed 55˚C for silver plated joints and 40˚C for other joints, over an ambient temperature of 50 ˚C under any condition.

3) CT/PT/Meters (As required for the system offered & shall be suitable for variable frequency operation.)

4.03.00 CAPACITOR (as applicable)

Shall be self-healing film or electrolytic type having high life time. The capacitor shall be an integral part of VFD system. DC link Capacitors shall have discharge resistors which shall be capable of reducing the residual charges to zero just after the capacitor is disconnected from the supply source. The capacitor shall be suitable for high ripple currents.

4.04.00 POWER CONTROLLER

1) Housing

Metal enclosure panel having IP-42 degree of protection, located in indoor environment fabricated from cold rolled sheet steel of Frame thickness 2.0mm, Enclosure thickness 1.6mm & Gland plate thickness 4.0mm(Al).

2) Control & Protection

Protection shall be provided against overload, AC/DC transients, voltage surge, etc. of power & control device. Duplicate control supply with automatic changeover shall be provided.

3) Construction

Proper ventilation shall be provided in the panels to ensure that max. temperature inside the cubicle is within permissible limits for reliable and continuous operation of the system. In case cooling fans are provided, the same shall have 100% redundancy with provision for auto start of standby fan. The noise level inside the room shall be within the specified limits.

4) Control system shall be provided with 21”TFT with keyboard and colour laser printer located in the control room for system alarm and monitoring. Each drive panel shall be provided with its own graphical local control panel which shall offer programming and parameter monitoring facilities with display and alarms. Provision shall be kept for exchange of information between VFD control system and DDCMIS/DDC/Field bus.

5) Copper earth bus of min. 50x6 mm size shall be provided in the panel with provision for connection to Owner/Purchaser’s plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system as required shall be provided.

6) All the control wiring shall be enclosed in plastic/metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes of PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, copper conductor wire. 1.5mm2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5mm2 size for control fuse rating above 16A for electrical circuits and 0.7 mm2 for electronic

circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminal shall be provided.

4.05.00 MOTORS

Three phase squirrel cage Induction motor with VPI insulation & inverter grade duty suitable for VFD application. These motors shall be provided with insulated bearing on one side. Motors shall also meet the requirements mentioned in sub-section for Motors and relevant IS/IEC.

4.06.00 CABLES

Power cables used to interconnect the VFD to motor shall have multi-stranded, aluminium/copper conductors. These cables shall be XLPE insulated, metallic screened, PVC inner sheathed, armoured, PVC outer sheathed, round and symmetrical with three symmetrically positioned insulated grounding conductors. The metallic screen of each core shall consist of copper wires or tape with minimum overlap of 20%.Cables shall also meet the requirements mentioned in subsection for cables and relevant IS/IEC.

5.00.00 TYPE TESTING

5.01.01 The contractor shall submit for Employer's approval the reports of all the type tests as listed in this specification and carried out within last ten years from the data of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. In case the Contractor is not able to submit report of the type test(s) conducted within the last ten years from the date bid opening, or in case the type test report in not found to be meeting the specification requirements, the Contractor shall conduct all such tests under this contract free of cost to the Employer and submit the reports for approval.

5.01.02 All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

5.02.00 LIST OF TESTS

5.02.01 Routine tests

a. Visual Inspection

It involves checking of the various equipment/components fault diagnostic unit, wiring, terminals, earthing ratings etc, in line with the approved drawings and visual inspection shall not be limited to the following:

i) Dimensions and door layout vis-a-vis the approved drawings

ii) Degree of protection of cubicles

iii) Simulation facility of control signals for testing purposes

iv) Memory function of fault diagnostic

v) Voltage/Current rating power semiconductor elements

vi) Cable termination size and number of terminals, cable-supporting etc.

vii) Accessibility of components

viii) External signals and indication/alarm signals on converter

ix) Earthing of cubicles and cubicle doors.

b. Insulation Test

c. Light load and functional test

d. Load characteristics test

e. Load duty test

f. Checking of Auxiliary devices

g. Checking the properties of the control equipment

h. Checking the protective devices

i. Checking of control and functional requirements

j. High voltage test

k. Shaft current/bearing insulation

l. Automatic restart/re-acceleration

5.02.02 Type Tests

a. Allowable full load current versus speed

b. Efficiency

c. Temperature rise

d. EM Immunity

e. EM Emission

f. Current sharing

g. Voltage division

h. Line side current distortion content

i. Power factor

j. Audible noise

k. Torque pulsation

l. Motor vibration

m. Dynamic performance

n. Current limit and current loop test

o. Speed loop test capability to ride through voltage less than 80%

p. Test capability to restart the system and resynchronize converter onto running motor after a voltage interruption

Type test certificate from independent testing agency for similar equipment can be accepted for d, e, f, j, k and l at the option of the owner / purchaser.

LIST OF VFD OPERATED HT MOTORS

Sl. No.	Equipment	Total Number (Working + Standby)	Motor Rating (KW)
1.	Boiler Feed Pump	3 (2 + 1)	2000
2.	ID Fan	2 (2 + 0)	1600
3.	PA Fan	2 (2 + 0)	1650
4.	SA Fan	2 (2 + 0)	1000

DATA SHEET – LT VFD

Sl. No.	Description	Unit	Specification Requirement
1.0	Type of drive		Inverter (IGBT based PWM controlled) AC drives
2.0	Manufacturer		*
3.0	Application		Fans/Pumps
4.0	Type of Motor/Model No. of the VFD		VFD shall be considered as per the technological requirement
5.0	Rating of drive	kW	Squirrel cage induction motor
6.0	Quantity		*
7.0	Rated power factor		*
8.0	Efficiency		*
9.0	Rated output voltage	kV	*
10.0	Full load current	kA	*
11.0	Type of duty		a)100% continuous b) 150% overload for 1 minute in 24 hours
12.0	Quadrants of operation		*
13.0	Full wave rectification		12 pulse
14.0	Power supply system		
	a)Input power supply		415V, 3 ph, 50Hz
	b)Variation in voltage		±10%
	c)Variation in freqnecy		±5%
	d)Combined voltage & frequency variations		10%
	e)System faultl level	kA	65 kA 1 sec
	f)Type of earthing		Solidly earthed

Sl. No.	Description	Unit	Specification Requirement
15.0	Location		Indoor
16.0	Type of cooling		*
17.0	Input and output cables		
	a)Size & type		*
	b)Entry		Bottom
18.0	Dimensions		*
19.0	Degree of protection		IP42
20.0	Power losss ride through time	Sec.	2
21.0	Control characteristics		
	a) Control Method		Drive level control using digital system.
	b) Output freq. range		*
	c) Frequency accuracy		0.01%
	d) Frequency resolution	Hz	0.001
	e) Speed regulation		0.5% of max. speed
	f) Speed range		*
	g)Accelerate/decelerate time		*
	Harmonic limitations		
22.0	I)Voltage harmonics		
	a)Source side		Maximum 5%
	b)Load side		Maximum 5%
	II)Current Harmonics		
	a)Source side		
23.0	i) 5^{th}		Maximum 30%

Sl. No.	Description	Unit	Specification Requirement
	ii) 7th		Maximum 20%
	iii) 11th		Maximum 10%
25.0	Miscellaneous		
	a)Soft-start		Yes
	b)Flying restart		Yes
	c)Auto restart		Yes
25.0	Kinetic buffering		Yes (Preferably for a backup time of 2 sec.)
Note	**'*' indicated above shall be filled by the Contractor**		

DATA SHEET- HT VFD

Sl. No.	Description	Specification Requirement
1.0	Type	Metal Clad, draw out
2.0	Service	Indoor
3.0	Enclosure	IP 42
4.0	Motor Output	Motor Manufacturer's data sheet shall be referred.
5.0	Motor rated current, Amps	Motor manufacturer's data sheet shall be referred
6.0	Motor rpm	Motor manufacturer's data sheet
7.0	Rotor type	SCR
8.0	Application	As mentioned in the Scope of supply
9.0	Speed range	Shall be fully compatible to the specific pump operating range.
10.0	Service Voltage	11 kV + 10.0%
11.0	Frequency	50 Hz + 5%
12.0	System Efficiency	□ 95% at 100% speed & 100% load inclusive of all losses.
13.0	Power Factor	0.96 continuous *
14.0	Full wave rectification	36 pulse
15.0	Output Frequency Resolution	0.01 Hz
16.0	Overload Capacity	120% of rated current for 1 minute; 150% immediately.
17.0	Microprocessor-based : multi-level switching	IGBT-PWM

Sl. No.	Description	Specification Requirement
18.0	DC link capacitors	Electrolytic type
19.0	Voltage cut ride through duration	5 Cycles
20.0	Cooling	Air cooling
21.0	Max. ambient temperature	50 deg. C
22.0	Logical Control I/O Signals	Expandable
23.0	Converter Duty Transformer	As required
Note	**'*' indicated above shall be filled by the Contractor**	

BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL
DATA SHEET FOR BFP MOTOR

Project Name	DCM SHRIRAM 1X120MW STG		
Client	DCM SHRIRAM CONSOLIDATED LTD		
BHEL WO :	40050A421-11		
		Rev.00	Date: 12-Oct-2020

Note1: Data given below is subject to tolerance as per IS/IEC 60034-1 unless specified otherwise.

A. AC MOTOR

1.0	**GENERAL**		
1.1	Application		: BFP
1.2	Quantity		: 03
1.3	Make		: BHEL, Bhopal
1.4	Frame Size		: 2RQ 7632-2
1.5	Applicable Standard		: IS/IEC 60034-1
2.0	**TYPE AND RATING**		
2.1	Type of Motor		: SCIM
2.2	Service		: 1.0
2.3	Duty Cycle/Designation		: Continuous, S1
2.4	Rated Continuous Output		
	At 40 Deg.C ambient	KW	: 2350
	At 50 Deg.C ambient	KW	: 2200
2.5	Rated Speed	r.p.m.	: 2990
2.6	Rated Voltage & % variation		: 11kV ± 10%
2.7	Rated Frequency & % variation		: 50 ± 5 %
2.7a	Combined frequency and voltage		: 10%
2.8	Full load current	Amps	: 133
2.9	No load current	Amps	: 34
2.10	Rated Power Factor		: 0.91
2.11	Efficiency at rated voltage and frequency:		
	a) Full load	%	: 95.8
	b) 3/4 load	%	: 95.5
	c) 1/2 load	%	: 94.5

3.0 **PERFORMANCE**

3.1 Method of Starting : DOL & VFD

3.2 Starting Current at rated voltage % flc. : 600% on DOL start

3.3 Starting Current at 110% voltage (% of full load current) : 660% on DOL start

3.4 Torque at rated voltage kg.m :

a)	Breakaway starting torque kg m		: 358 (50% FLT)
b)	Pull out torque	kg. m	: 1646 (230% FLT)
c)	Pull up torque	kg m	: 358 (50% FLT)
d)	Full load torque	kg. m	: 716

3.5 Starting time at :

			80% Voltage	100% Voltage	110% Voltage
a) Motor with coupling					
i)	With load	sec.	: 13.0	7.0	6.0
ii)	Without load (driven equipment coupled)	sec	: 7.0	4.5	3.5

3.6 Safe stall time at

			80% Voltage	100% Voltage	110% voltage
a)	Hot condition	sec.	: 37	24	19
b)	Cold condition	sec.	: 46	30	24

3.7 Frequency of start per hour

a)	Hot condition	: 2
b)	Cold condition	: 3
c)	Equal spread start	: 3

3.8 Heating Time Constant (min) : 30

3.9 Cooling Time constant (min) : 120

3.10 Negative sequence time constant ($K=I_e^2t$) : Refer Curve No. AM40051-11/05

3.11 Noise level : 90 dB at 1m.

3.12 (i) Bearing Vibration level : 2.3 mm/s(rms) 37 µ (rms)
(ii) Shaft vibration : 65 µ (P-P)

4.0 **CONSTRUCTION**

4.1 Degree of Protection of Enclosure : IP55

4.2 Method of Cooling : CACA, IC611

4.3 Insulation :

a) Type : VPI, Resin Poor

b) Class : Class F (Temp. rise limited to Class B)

4.4 Temperature Rise Over 50 Deg.C ambient (by resistance) : 70

4.5 Tropicalized Yes/No : YES

4.6 Winding Connection : STAR

4.7 Bearings D.E. N.D.E.

a) Make : DIN Bearing, BHEL Approved/ From GeM

b) Type : Sleeve

c) Recommended lubricant : ISO VG32 or equivalent

d. Duration of lubrication change : FOL system vendor to recommend.

e. Life of bearing : Infinite (if properly maintained)

f. For force oil lubrication system : Not in BHEL, Bhopal scope

i) Oil flow per bearing (LPM) : 3.5 for each bearing

ii) Max/ Min oil pressure (kg-m^2) : 0.2-0.5 kg/cm^2

4.8 Motor Terminal Box

a) Type : PSTB

b) Fault withstand Current KA : 50 (through fault)

c) Fault Current Withstand Time Sec. : 0.25

d) Cable lugs & glands furnished Yes/No : Gland Furnished, Lug is not in BHEL,Bhopal scope.

e) Position : RHS from DE

f) Rotation 360 deg with step of 90 deg. (yes/No) : Suitable for 360 º rotation in step of 180º

g) Type of thread : BSC

4.9 Mounting

a. Shaft extension : Refer OGA drawing

b. Direction of rotation from DE side : CCW from DE

4.10 Motor Neutral Terminal Box

a) Type : Non-PSTB

b) Differential CT provided (Yes/No) : 3 Nos.

4.11 Rotor terminal box : NA

5.0 **ACCESSORIES**

5.1 Space Heaters

a) No. x Watt : 2 X 600W

b) Volt, phase, frequency : 240V, 1Ph, 50Hz

5.2 Winding temperature detector

a) Type : PT100 Simplex, 3 lead

b) Nos. furnished : 12

5.3 Bearing temperature detector

a) Type : PT100 Duplex, 3+3 lead

b) Nos. furnished : 2

5.4 Hot and cold air temperature detector

a. Type : PT100 Duplex, 3+3 lead

b. Nos furnished : 1 +1

5.5 Temperature Indicators

a) Type : Gas filled Dial Type

b) Nos. provided : 2 Nos. for Bearings.

c) Locations : On bearing housing

5.6 Temperature Alarm Contact

a) Nos. provided : 2 'NO'

b) Locations : In-built inside DTT

c) Contact rating : 30W, 50VA

5.7	Flow Switch		
	a.	Type	: NA
	b.	Nos. provided	:--
	c.	Locations	: --
	d.	Contact Rating	:--
5.8	Current Transformer for differential protection		
	a.	Nos. provided	: 3 Nos.
	b.	Current Ratio	: Customer to decide details.
	c.	Class	: PS
5.9	Speed Switch		
	a.	Type	: NA
	b.	Location of switch & terminal box.	--
	c.	Auxiliary supply requirement	: -
	d.	Catalogue furnished	: --
5.10	Starting Resistance (slip ring motor)		: NA
	a.	Type	: --
	b.	Rating	: --
5.11	Accessory Terminal Box		
	a)	No. provided	: 1
	b)	Cable glands furnished	: Yes/No: YES
5.12	Insulation of bearing		: YES, at NDE
5.13	Lubrication oil level indicator		: Sight glass on bearing housing.
5.14	Water flow indicator		: NA
5.15	Water leakage detector		: NA
5.16	Vibration Pad (Nos. size and location): 2 Nos., 80 X 80 X 80 mm^3		
5.17	Motor vibration sensor		: Not in BHEL Bhopal Scope.
5.18	Any other fitment		: NA

6.0	**GROUNDING**			
6.1	No. of grounding pads provided			
	a) On motor body			: 2
	b) On terminal box			: 2
7.0	**MISCELLANEOUS**			
7.1	Type of mounting			: Horizontal, B3
7.2	Foundation bolts provided (Yes/No)			: In Pump vendor scope.
7.3	Overall dimension (LxBxH) mm x mm x mm			: ≈ 4200 X 3200 2800
7.4	Moment of Inertia (Sq.GD)			
	a) Stator	Kg.Sq.m		: NA
	b) Rotor	Kg.Sq.m		: 296
	c) Total	Kg.Sq.m		: 296
7.5	Weight			
	a) Stator+Cooler		Kg	: 9500 + 1800
	b) Rotor		Kg	: 2700
	c) Total		Kg	: 14000

Motor Equivalent Circuit Parameters:

Stator:

R1 = 0.165
X1 = 6.48 Ohm
Xm =195.72 Ohm

Rotor:

R2'=(referred to stator)=0.782 Ohm at starting
= 0.242 Ohm during running

X2' (referred to stator) = 2.95 Ohm at starting
= 4.19 Ohm during running

FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN mm)

DRG. No. 3-661-00-00978

REF. DRG. No.

SIGN. & DATE

INVENTORY No.

11 kV, 50Hz, 3ph (CUSTOMER SCOPE) FAULT LEVEL 50kA FOR 1 SEC

VCB (CUSTOMER SCOPE)

CT

220V DC REDUNDANT SUPPLY (CUSTOMER SCOPE) ⊛

220V DC SUPPLY(CUSTOMER SCOPE),COMMON TO Q1 & Q3 ⊛

230V AC 1PH SUPPLY(CUSTOMER SCOPE), COMMON TO Q1 & Q3 ⊛

Q1 VCB (BHEL EDN SCOPE)

VCB Q1 ON COMMAND

VCB Q1 OFF/TRIP COMMAND

VCB Q1 ON FEEDBACK

VCB Q1 OFF FEEDBACK

FROM VCB (D)

EPB OPERATED FEEDBACK

L/R SELECTED FEEDBACK

VCB TRIP FEEDBACK

VCB ON FEEDBACK

VCB Q1 ON FEEDBACK

VCB Q1 OFF FEEDBACK

VCB Q1 TRIP FEEDBACK

TO VCB (C)

VCB ON COMMAND

VCB OFF COMMAND

EMERGENCY STOP

BYPASS(DOL) MODE

DOL START

DOL STOP

DCS FOR REMOTE OPERATION (CUSTOMER SCOPE)

DOL START PERMISSIVE

VCB Q3 ON FEEDBACK

VCB Q3 OFF FEEDBACK

VCB Q3 TRIP FEEDBACK

DOL MODE CURRENT

SPEED REFERENCE(4–20mA)

CURRENT FEEDBACK(4–20mA)

SPEED FEEDBACK(4–20mA)

VFD READY/ RUN PERMISSIVE

VFD TRIP FEEDBACK

VFD IN REMOTE MODE

VFD RUN FEEDBACK

VFD ALARM FEEDBACK

VFD TEMP FEEDBACK

VFD START COMMAND

VFD STOP COMMAND

VFD MODE

EMERGENCY STOP

MODBUS(RS485)

VFD (VSI TYPE) WITH INTEGRATED DRY TYPE TRANSFORMER

EMERGENCY STOP

START

STOP

LOCAL MODE

REMOTE MODE

TO VCB Q3 (A)

EMERGENCY STOP

VFD START

VFD STOP

LOCAL SELECTION

REMOTE SELECTION

SPEED INCREASE

SPEED DECREASE

VFD TRIP

VFD HEALTHY/RUN PERMISSIVE

VFD RUN

VFD MODE

MOTOR CURRENT(4–20mA)

MOTOR SPEED(4–20mA)

LOCAL CONTROL STATION (VFD–LCS) (BHEL EDN SCOPE)

DOL START PERMISSIVE

DOL MODE INDICATION

DOL MODE CURRENT (4–20 mA)

(B)

240V,1PH,200VA, AUX SUPPLY ⊛ (CUSTOMER SCOPE)

Q3 VCB

MPR CT

87M CT

(A)

(B)

(BHEL EDN SCOPE)

VCB Q3 OFF FEEDBACK

VFD RUN

AUX SUPPLY,415V,3ph(CUSTOMER) ⊛

10kVA continuous,40kVA FOR 5 SECS

110V,1ph UPS SUPPLY, 1 kVA ⊛

(CUSTOMER SCOPE)

ISOLATOR Q2 ON FEEDBACK

(BHEL EDN SCOPE)

Q2 ISOLATOR (MOTORISED) (BHEL EDN SCOPE)

ISOLATOR Q2 ON COMMAND

ISOLATOR Q2 OFF COMMAND

ISOLATOR Q2 ON FEEDBACK

ISOLATOR Q2 OFF FEEDBACK

110V,1ph UPS SUPPLY ⊛ FEEDER

240V,1ph,50HZ FOR MOTOR SPACE HEATER

MOTOR WDG TEMP

MOTOR BEARING TEMP. DE& NDE

MOTOR VIBRATION

CT FOR MOTOR DIFFERENTIAL PROTECTION

M

CT

(BHEL–BHOPAL SCOPE)

BFP MOTOR

BFP MOTOR RATING	SQUIRREL CAGE INDUCTION MOTOR 11 KV, 50 HZ, 2350KW
IP CLASS	VFD PANEL : IP42 VCB PANEL : IP4X ISOLATOR PANEL: IP42 LCS PANEL : IP55
DESIGN AMBIENT	50 DegC

⊛ FINAL RATING DURING DRAWING APPROVAL STAGE

(a) ALL HT POWER CABLE, HT CABLE TERMINATION KIT, LT POWER CABLE, LT CONTROL CABLE AND INSTRUMENTATION CABLE IN CUSTOMER SCOPE.

REV.	DATE			REV.	DATE		
02	08.07.2020	ALTERED	KD	01	01.06.2020	ALTERED	KD
		CHECKED	LSL			CHECKED	LSL
		APPROVED	LSL			APPROVED	LSL
	CUSTOMER COMMENTS INCORPORATED				CUSTOMER COMMENTS INCORPORATED		

	NAME	SIGN	DATE
DRAWN	KD		05.05.2020
CHECKED	LSL		05.05.2020
APPROVED	LSL		05.05.2020

DISTRIBUTION OF PRINTS

DEPT. CODE

PROJECT – STG PACKAGE FOR 1 x 120 MW COAL BASED DCM SHRIRAM LIMITED, GUJARAT

CONSULTANT – DCPL, KOLKATA

BHARAT HEAVY ELECTRICALS LIMITED.
ELECTRONICS DIVISION, BANGALORE

CARD CODE

TITLE: SLD FOR VFD SYSTEM

No. OF SHEETS	02
SHEET No.	01
REV	02

M.O. No. CE/1654–PR1–70–01

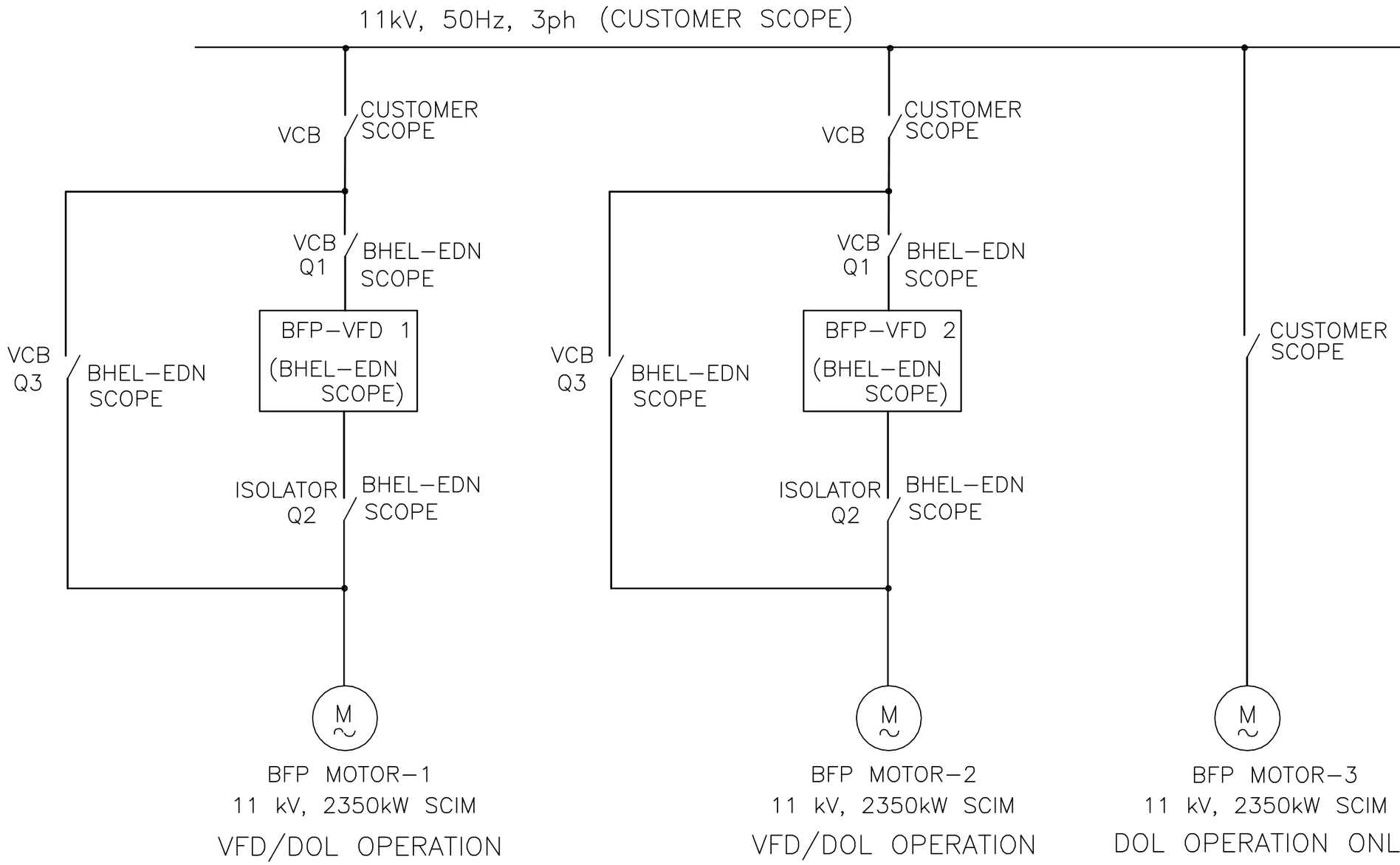
AS PER OPEN TOLERANCE TO ED 0230499

DRG. No. 3–661–00–00978

FORM No. A3–03

A3 SIZE

DRG. No. 3-661-00-00978



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M.O. No.	CE/1654-PR1-70-01	AS PER OPEN TOLERANCE TO ED 0230499	DRG. No. 3-661-00-00978

REF. DRG. No.
SIGN. & DATE
INVENTORY No.

FORM No. A3-03

A3 SIZE