REVISION HISTORY SHEET

REV. NO.	DATE	NATURE OF CHANGE	REASONS	PREPARED BY	APPROVED BY
00	19-01-2021	FIRST ISSUE	------		

REVISIONS 00

APPROVED BY
L SUBBALAKSHMI

PREPARED BY	ISSUED BY	DATE
GITESH DAS	CE-T&PD/COE	19-01-2021

TECHNICAL SPECIFICATION OF IGBT/ IGCT/ SGCT BASED VFD FOR 5150 kW, 6.6kV SQUIRREL CAGE INDUCTION MOTOR FOR WET GAS COMPRESSOR

1. Project Details

Sl. No.	Parameter	Specification
1	Project Location	HPCL Rajasthan Refinery Ltd., Barmer, Rajasthan, India
2	Project Title	Delayed Coker Unit (DCU), Wet Gas Compressor (WGC) Project
3	Customer	HPCL Rajasthan Refinery Ltd. (HRRL)
4	Customer's Consultant	Engineers India Limited (EIL)
5	LSTK Contractor	Tata Projects Ltd., Mumbai
6	LSTK Contractor's Consultant	Aker Solutions, Mumbai

2. Environment Specifications

Sl. No.	Parameter	Specification
1	Maximum Ambient Temperature	48.2°C
2	Minimum Ambient Temperature	3.4°C
3	Equipment Design Temperature (IS-9676)	45°C
4	Relative Humidity	100% @ 48.2℃
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-III

3. Input and Transformer Data :

Sl. No.	Parameter	Specification
1	System Voltage / Frequency / Phase	6.6kV / 50Hz / 3
2	Voltage Variation	±10%
3	Frequency Variation	±3%
4	Combined Voltage and Frequency Variation	±10%
5	Fault Level	40kA/3 sec
6	Transformer Type	Dry type integrated Transformer (In Vendor scope), Indoor
7	Rating	Transformer must be designed to carry 110% of calculated VFD rating. Transformer sizing calculation shall be provided along with offer.
8	Power Cables	Cable glands and termination suitable for 3RX3CX300 sq.mm. Al, XLPE cable to be provided by the vendor for Transformer HV side cable termination. The exact cable sizes will be intimated during drawing approval stage. Cables and termination kits in Customer scope.

4. Motor Data :

Sl. No.	Parameter	Specification
1	Type	Squirrel Cage Induction Motor
2	Scope	Manufactured by BHEL-Bhopal
3	Rated Output	5150kW, 1496 RPM
4	Rated Voltage and Current	6.6kV, 516A
5	Pull Out Torque (% of FLT)	175%
6	Fed from	Variable Frequency Drive (V/f Control) with DOL Bypass
7	Duty Class	Refer attached motor datasheet
8	Efficiency and Power Factor:	% of Load / Efficiency / Power Factor 75 / 96.6% / 0.90 100 / 97% / 0.90
9	Power Cables	Cable glands and termination suitable for 3RX3CX300 sq.mm. Al, XLPE cable to be provided by the vendor for VFD Output side cable termination. The exact cable sizes will be intimated during drawing approval stage. Cables and termination kits in Customer scope.

5. Scope:

Sl. No.	Scope of Supply	Description
1	a) 1 No. Fully Assembled Unit of 6.6kV VFD Panel (IGBT/SGCT/IGCT), Air Cooled with integrated Dry type transformer and with Synchronous Bypass feature for bumpless transfer from VFD to DOL and vice versa; Output choke for synchronization, if required, Output PT for synchronization b) All interconnecting cables between the VFD and integrated Transformer. c) One number of Local Control Station (LCS) mounted near motor. d) Power Cable glands (Flame proof) and hardware for VFD and Transformer, Cable glands (Flameproof) and lugs for LCS. e) Any special cable other than power and control cables from VFD to other equipment. f) Any special tools and tackles. g) Mandatory Spares and Commissioning Spares.	The vendor shall be responsible for engineering and functioning of the complete VFD system comprising of dry type transformer and VFD panel, meeting the intent and requirement of this specification, EIL specification and datasheet. 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, motor cable selection etc. VFD shall be provided with Synchronous bypass features. VFD panel shall include PT or any other device and any other hardware for synchronization of output breaker and bypass breaker. **(Bus PT shall be in customer scope).** All necessary interlocks as required for safe and reliable operation of VFD system along with Input breaker, Output breaker and Bypass breaker shall be provided in VFD system. The machine shall normally run on VFD. However at the discretion of the operator, it shall be switched on to bypass after synchronization with the VFD feeder. The transfer should be bumpless from VFD to DOL and vice versa. 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 for Synchronous Bypass shall be in vendor's scope

6. VFD Specifications

Sl.	Parameter	Specification
1	Drive	Wet Gas Compressor
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 3-661-00-00979 REV.03
5	Output Voltage of VFD	0 to 6.6kV (V/f = Constant)
6	Output Current of VFD	516A at 45°C (Design Ambient)
7	Output Frequency	0 to 50Hz , Resolution: +/- 0.01% under transient conditions; +/- 0.5% under steady state conditions
8	Speed Regulation	+/- 0.5%
9	Speed Accuracy	+/- 1%
10	Over load Capacity	110% of rated current for one minute at rated voltage
11	Drive Control	Sensorless Vector Control
12	Braking Operation	Not Applicable
13	Output LC Sinusoidal Filter	Motor is designed for PWM operation. Distance between VFD and Motor is ~355 meters. Vendor to clarify and offer output Filter, if required. If O/P filter is required then the cables between VFD and filter will be in vendor scope. Cable glands, lugs and termination kit for the cables at both the end of the filter must be supplied by vendor.
14	VFD Panel Construction	a) Protection Class: IP31 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: Air Cooled. Cooling system shall include well dimensioned panel with 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 fans (minimum N+1) as per EIL specification. Suitable thermal switch for exit air temperature monitoring shall also be incorporated. d) Earth Bus – minimum 50*6 mm Copper shall be provided with provision for connection to plant earth grid.

Sl.	Parameter	Specification
14	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 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. The panel shall be spray painted with two coats of Epoxy Based final paint with Powder Coated Finish - shade RAL7032 (Pebble Gray), Paint Thickness: 80 Microns (minimum). h) Power and Control Wiring shall be done with Fire retardant cables as per EIL Specification. i) Double compression type Nickel plated brass flame proof cable glands shall be supplied. 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 equipment shall be used. k) All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.

Sl. No.	Parameter	Specification
15	Noise Level	Shall be less than 85dB at a distance of 1 metre from the outline of VFD Panels at a height of 1.5 metres from the floor with all the fans running in the VFD Panels.
16	Storage Temperature	-40°C to +60 °C
17	Vibration	According to IEC68-2-6
18	Interference	According to IEC801 parts 2,3,4 Immunity: The panels shall be designed so as to have low Radio Frequency Interference (RFl) and Electromagnetic Interference (EMl).
19	VFD Efficiency	Shall be **> 95%.** Exact value to be specified by the Vendor.
20	Duty Cycle	Class I Duty Cycle as per IEC 146-1
21	VFD Requirements	a) Input Choke: Input chokes to be provided if necessary. b) Local/Remote: Selector switch shall be provided on VFD panel for operator to select type of operation: Local – Refer attached SLD Remote –Refer attached SLD 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) VFD/Bypass mode Selector switch (Lockable) to be provided on the VFD panel. d) Local Start/Stop Push Button to be provided either on panel door or on keypad. e) Door Mounted Lockable Push-Button to be provided with 4NO + 4 NC contact for Emergency Stop. One normally open contact to be wired to Terminal Block for external Interlocking / Annunciation. f) 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. g) 240V, 1phase, 50Hz, 1000W (approximate, exact value 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.

Sl. No.	Parameter	Specification
21	VFD Requirements	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 & protection of VFD system shall be considered by the VFD vendor in their scope.
22	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) 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. **The Panels shall be Vacuum packed before sending to Site.** n) Vendor shall certify readiness of system fit for commissioning. Vendor's scope shall also include supply of all specialized tools and tackles required.

		o) VFDs shall be installed in Air-conditioned area but it shall be suitable for operation in non-air-conditioned area also. p) Earthing scheme should be provided by the vendor. q) Any special cable other than power and control cables required to connect VFD to other equipment shall be in vendor scope. r) **<u>All Electronic PCBs/Modules must have conformal coating to take care of harsh site conditions. Acceptable coatings are ISA-G3 or ISA-GX or 3C2.</u>**
23	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 manual adjust the speed reference. In case the above operation is not possible through operator interface, vendor has to supply one laptop loaded with driver software along with a suitable communication cable for interface with VFD. c) The operator interface shall have LED indicators for drive fault, drive run etc. 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: ➢ Local/Remote selection ➢ VFD/Bypass Selection ➢ Emergency stop ➢ Synchronous Bypass operation ➢ Trip/Close Input breaker 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.
23	Controls and Monitoring	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) Output Frequency ii) Output Current iii) Motor Speed iv) Output Voltage v) DC Bus Voltage vi) Output Power (It shall be possible to display power output of the drive in kW) vii) Digital Input Status viii) Digital output status ix) Analog Input Status x) Drive Thermal state xi) Motor energy meter xii) Hour run l) Necessary transducer shall be provided with 4-20 mA 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: 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 Over speed x) Input Breaker Trip xi) Motor zero speed xii) Rectifier output 'ON' xiii) Transformer winding temperature alarm & trip

Sl. No.	Parameter	Specification
23	Controls and Monitoring	n) The VFD shall store fault logs of minimum last 10 faults in memory. 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 & alarm 9) Communication and measurement system unhealthy
24	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 105% of the VFD's rated full load output current) c) Ground Fault Protection – 5-10A within 250ms 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

Sl. No.	Parameter	Specification
24	Protection	j) Heat sink over temperature/VFD Panel Temperature High Stall prevention (During acceleration, deceleration and constant speed operation) 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 motor input current and torque for the complete speed 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.
25	Local Control Station (Flame proof) Features Gas Group IIA/IIB	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 Dark admiralty grey of shade 632 of IS-5 /RAL 7031. Exact 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 the external surface of the 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) All control switches shall be provided with a pistol grip handle.

i) 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 (0-750A)
      ii) Actual Speed(0-1500rpm)
   2) 0-1A signal for display of Bypass Current with suppressed scale 0-750A/3750A

j) The sub-vendors of LCS shall be as follows:
   i) FCG POWER INDUSTRIES PVT LTD
   ii) BALIGA LIGHTING EQUIPMENTS (P) LTD
   iii) STAHL INDIA
   iv) FCG POWER INDUSTRIES PVT LTD
   v) FCG FLAMPROOF CONTROL GEARS P. LTD
   vi) FLAMEPROOF EQUIPMENTS PVT.LTD
   vii) FLEXPRO ELECTRICALS PVT LTD

k) Double compression Nickel plated brass cable glands (Flame proof) and tinned Copper lugs for cable termination shall be provided by the vendor.

l) 230V AC Control supply to LCS shall be provided by Customer.

m) Push Buttons with 2NO + 2NC contacts
   1. VFD/Bypass Start & VFD/Bypass Stop
   2. Emergency Stop
   3. Speed Increase
   4. Speed Decrease

n) Switch:
   1. Local/Remote Selection

o) Indications:
   1. VFD Fault
   2. VFD Ready to Start
   3. VFD Running
   4. VFD Mode
   5. Bypass Ready to Start

26	Dry type Transformer	Dry type Transformer a) HV voltage: 6.6kV 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: F or higher Protection: RTDs (2 nos.) to be provided in each limb for winding temperature measurement. Temperature scanner to be provided for winding temperature 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 3RX3CX300 sq. mm, Al, XLPE cable. Cable glands to be provided by the vendor. The exact number and size will be intimated during drawing approval stage. Cables in customer scope. LV Connection: Cables between LV secondary 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 at Vendor's works.
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 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.
29	Harmonics at VFD Output / Motor Input	Shall be as per IEC 61800-4

		Vendor to specify the maximum amount of voltage and current harmonics at the VFD Output / Motor Input terminals.
30	Switching frequency	To be specified by the vendor
31	Auxiliary Supply	a) 110V DC/ 240V Single Phase UPS feeder is provided by the Customer. Power supply for electronic modules has to be derived from the same. Feeder kVA/Amps Rating required is to be given by the Vendor. b) 1no. of 415V, 3Ph, 4-Wire, 50Hz feeder shall be provided by customer for VFD auxiliary power requirement (Fans, Space Heater, etc.). Feeder Power rating (short time & continuous) to be specified by the Vendor. c) 230V AC, non-UPS supply for LCS shall be provided by Customer. Feeder rating to be specified by the Vendor. d) Other supplies required by the VFD system to be generated internally within the VFD system.
32	Warranty	All equipment/goods supplied shall be warranted for 12 months from the date of commissioning or upto 31st December 2023 whichever is earlier. Replaced/repaired equipment/material will be warranted for 12 months from the date of repair/replacement or 31st December 2024 whichever is earlier. Vendor to also quote for 5 years comprehensive AMC which shall be applicable after expiry of warranty as mentioned above. **Please refer PWCAMC format & Page no. 19 to 21 of Job Specification (Electrical) (B224-114-16-50-SP-7204 Rev.B) attached with this Specification**.

33. SPARES

Sl. No.	Parameter	Specification
A	Mandatory Spares and Commissioning Spares	Supplier should quote item wise price for the following spares. Unpriced List of Spares quoted for shall be provided in the Technical Offer. **Vendor to quote for both Mandatory and Commissioning Spares.**

Sl . no.	Items	Mandatory Spares	Commissioning Spares
1	Complete Power Cell containing Rectifier & Inverter with Gate Driver Modules, etc. for one to one replacement at site OR Separate Converter & Inverter Module containing Rectifier Diode/IGBT / IGCT /SGCT, etc. with Gate Driver Modules	10% of the total quantity of Power cells or 1no. (min of each rating, whichever is more) **OR** 10% of the total quantity of converter & Inverter module (containing Rectifier Diode/IGBT/IGCT/SGCT & Gate Driver modules) or 1no. (min of each rating, whichever is more **Note- "OR" option is based on VFD construction of the Vendor**	-
2	Transistors /IGBT/IGCT/ Other Power Semiconductor devices along with gate driver	-	1 no. of each rating & type
3	Control Cards	1 no. of each type	1 no. of each type
4	Power supply card and Power supply module	1 no. of each rating & type	1 no. of each rating & type
5	Power fuses	20% of each rating or 1 no. (min) of each rating, whichever is more	1 no. of each rating & type
6	Control fuses / MCB	10 nos. of each rating & type	1 no. of each rating & type
7	Contactors	10% of each type or 1 no. (min) of each rating, whichever is more	-
8	Indicating Lamps along with cover	20% or 3 no. (min) of each colour, whichever is more	-
9	CT/Hall effect CT	1 no. of each rating & type	-
10	Control Transformer	1 no. of each rating & type	-
11	Cooling fan	1 no. of each rating & type	-
12	RTD for Dry type Transformer	1 no. of each rating & type	-
12	HMI/Display unit for Drive	1 no.	-

Sl . no.	Parameter	Specification
34	Testing and Quality Plan	a) Routine Tests shall be carried out on Transformer, VFD panel and LCS as per relevant standards and attached EIL ITP. b) Type Test Certificates to be furnished and type tests to be conducted as per attached EIL ITP and relevant standards. c) During fabrication, the drive and Transformer shall be subject to inspection by EIL/Owner, or by an agency authorized by the owner to assess the progress of work, as well as to ascertain that only quality raw material is used.
35	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: Vendor shall be responsible to train the Owner's personnel at manufacturer's works and at Site. The training shall include detail operation, configuration, modification, calibration, troubleshooting, preventive/ breakdown maintenance etc. as a minimum. The outline and duration of this training shall be as follows: i)At manufacturer's works : Two Owner's Engineers for a period of at least Seven man days. ii)At site: Ten Owner's Engineers for a period of at least Seven man days c) Commissioning: Commissioning of VFD System at HRRL, Rajasthan 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.
36	Software for Computer Interface	This 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 (Modbus only) shall be provided.

37	Maintenance	The procedure for maintenance of VFD panels and the schedule thereof shall be provided by vendor during detailed engineering.
38	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 37 of Specification shall be furnished in the format below.

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

7. Scope of Supply & Services :

Sl.No.	Parameter	Qty
1.	a) Fully assembled unit of 6.6KV, 5150kW VFD panel (IGBT/IGCT/SGCT) with integrated dry type transformer with synchronous bypass feature for bumpless transfer from VFD to DOL and vice versa, Output choke (if required) alongwith power cables between choke and VFD, glands, lugs and termination kit for output choke. VFD panel shall include output PT for synchronization of Output breaker and Bypass breaker.	1 no.
	b) Flame proof Local control station	1 no.
	c) Cable glands, and hardware for power cable termination in VFD and transformer. Cable glands and lugs for all cable terminations in LCS.	1 set
2.	Mandatory spares for VFD	1 set
3.	Commissioning Spares for VFD	1 set
4.	Erection Supervision & Commissioning (Vendor to quote lumpsum commissioning charges for 15 days 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 To & fro charges, Local transport travel time, standby charge, lodging, Boarding, mobilization, demobilization, food, medical, insurance, accommodation, living / subsistence allowances and other incidental expenses etc.	1 lot
5.	Post Warranty Comprehensive Annual Maintenance Contract (PWCAMC) services charges as per attached format (Optional Price)*	1 lot

* : Optional prices shall be considered for bid evaluation. Applicability of PWCAMC shall be subject to customer confirmation on the same.

8. Documentation

Sl. No.	Parameter	Specification
1	Attached Documents	a) Single Line Diagram: B224-DCU-TPL-114-MR-DW-PR0001-0097 Rev. 03 b) Motor Data Sheet: B224-114-16-50-DS-1038 Rev. A c) Compressor Torque Curves: 4CM41600934 Rev00 d) EIL Standard Specifications for HV Variable Frequency Drive System: 6-51-0050, Rev.2 e) EIL Standard Specifications for Dry Type Distribution Transformer: 6-51-0044, Rev.5 f) EIL Standard Specifications for Flameproof Control Station: 6-51-0006, Rev.5 g) Datasheet for HV VFD: B224-114-16-50-DS-1036, Rev-A h) Dry Type Transformer Datasheet: B224-114-16-50-DS-1008, Rev-A i) ITP for HV VFD system: 6-81-1050, Rev02 j) ITP for Flameproof Control stations: 6-81-1006, Rev. 3 k) ITP for Dry Type Lighting Transformer: 6-81-1042_Rev02 l) Packing, Marking & Shipping instructions_Rev00 m) PWCAMC price format for VFD n) Job Specification (Electrical) (Page 19 to 21): B224-114-16-50-SP-7204 Rev.B o) Pre-Qualification Criteria.
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) Reference list for similar rating VFDs giving the following: Model number, Application, Rating, Year of supply and commissioning. c) Confirmation / Clarification / Information / Deviation List as per Point 6.38 (Page 17 of 20) above. d) Confirmation / Clarification / Deviation List to EIL Specifications and other documents in Sl no. (1) above e) Filled-up datasheet for VFD & Transformer f) Filled-up PWCAMC price format g) Technical Catalogue of VFD System being offered h) Design calculation for sizing of transformer and VFD i) Filled-up Pre-Qualification Format
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 Maintenance 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 20 for Unpriced and Priced bid from Sl.no. 7.1 to 7.5
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/DC 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 rating equipment as per respective ITP. j) Filled up Data sheet for VFD and Transformer
6	Information Required along with Supply. Maintenance Manuals and Documentation	a) Erection, Commissioning and Maintenance Manuals along with Final Drawings and Documentation b) Test and Guarantee Certificates. c) Complete Bill of Material (item wise) for the equipment supplied. All the above as built/ final tested documents shall be given in one number of CD-ROM.

DRG. NO. B224-DCU-TPL-114-EL-DW-PR0001-0097

6.6kV ± 10%, 50Hz ± 3%, 3ph, 40kA FOR 3SEC (PURCHASER-TPL SCOPE)

CONTROL LOGIC SELECTION TABLE :
(VFD/BYPASS SELECTOR SWITCH IN VFD)

VFD START (CONTROL LOGIC MADE IN VFD)			BYPASS START (CONTROL LOGIC MADE IN VFD)	
LCS L/R SW. POS.	VFD L/R SW. POS.	CONTROL FROM	BYPASS MODE SELECTED IN VFD	CONTROL FROM
LOCAL	LOCAL/ REMOTE	LCS	VFD/BYPASS SEL. SWITCH ON VFD PANEL (LOCKABLE) & LCS IN LOCAL OR REMOTE (L/R SW. POS.)	LCS
REMOTE	LOCAL	VFD		
REMOTE	REMOTE	DCS		

VCB Q1 — PURCHASER (TPL) SCOPE

VCB ON COMMAND
VCB OFF & VFD TRIP COMMANDS(2)
VCB TRIP PB
VCB ON FEEDBACK
VCB ON INDICATION
VCB OFF INDICATION
VCB TRIP INDICATION

3R x 03C x 300 Sq. mm Al, XLPE CABLE

(BHEL-EDN SCOPE)

SUBSTATION AUTOMATION SYSTEM (SAS) — PURCHASER (TPL) SCOPE

MODBUS TCP/IP #

SPEED SETPOINT 4-20mA (FROM IMCC)

FROM MMS:
MOTOR BRG TEMP ALARM/TRIP
MOTOR WDG TEMP ALARM/TRIP

READY TO START FBK
Q3 ON FBK
Q3 OFF FBK

DCS/PLC FOR REMOTE OPERATION — OWNER'S SCOPE

START PERM.
EMG. STOP

CURRENT FEEDBACK(4-20mA)
SPEED FEEDBACK(4-20mA)
REMOTE (DCS) MODE
LOCAL MODE
VFD MODE SELECTED
VFD READY TO START
VFD FAULT / TRIP
VFD RUNNING
BYPASS (DOL) MODE SELECTED
SPEED REFERENCE(4-20mA)
VFD START PERMISSIVE
EMERGENCY STOP

IGBT/SGCT/IGCT BASED DIODE FRONT END INVERTER WITH INTEGRATED DRY TYPE TRANSFORMER

(TAG NO. VFD-114-KM-1001)

EMG. STOP
BYP. START
BYP. STOP
LOCAL SEL.
REMOTE SEL.
TO VCB (Q3)

EMG. STOP
VFD START
VFD STOP
LOCAL SEL.
REMOTE SEL.
SPEED INC.
SPEED DEC.
VFD FAULT IND.
VFD READY TO START IND.
VFD RUNNING IND.
CURRENT FBK(4-20mA)
SPEED FBK(4-20mA)
VFD MODE

LOCAL CONTROL STATION (VFD-LCS) — (BHEL-EDN SCOPE)

BYPASS MODE CUR. (0-1A/0-630A/3150A)
BYPASS READY TO START INDICATION
*230V,1ph AUX SUPPLY, 200VA
FROM VCB (Q3)

VCB Q3 — PURCHASER (TPL) SCOPE

VCB ON COMMAND
VCB OFF COMMAND
VFD MODE SELECTED
BYPASS (DOL) MODE SELECTED
VCB ON FEEDBACK

REMOTE SEL.
LOCAL SEL.
BYPASS STOP
BYPASS START
EMG. STOP
FROM LCS

BYPASS MODE CURRENT
BYPASS READY TO START
TO LCS

*AUX SUPPLY,415V,3ph (FROM PURCHASER-TPL)
12kVA CONTINUOUS, 150KVA FOR 5 SEC

*110V DC SUPPLY (FROM PURCHASER-TPL)
1.0KVA CONTINUOUS

SYNCHRONOUS BYPASS UNIT

VCB ON COMMAND
VCB OFF COMMAND

3R x 03C x 300 Sq. mm Al, XLPE CABLE

VCB ON FEEDBACK

VCB Q2 — PURCHASER (TPL) SCOPE

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

3R x 03C x 300 Sq. mm Al, XLPE CABLE

TO DCS/PLC:
MOTOR WDG TEMP ALARM/TRIP
MOTOR BRG TEMP ALARM/TRIP

MACHINE MONITORING SYSTEM (MMS) (BHEL-HYD SCOPE)

MOTOR WDG TEMP. R,Y,B PHASES
MOTOR BEARING TEMP. DE& NDE

M

TO DCS/PLC:
SPEED SETPOINT (4-20mA)

IMCC PANEL NEAR COMPRESSOR (BHEL-HYD SCOPE)

SQUIRREL CAGE INDUCTION MOTOR, 5150kW
6.6kV, 516A, 50HZ (BHEL-BHOPAL SCOPE)

1) 2 NUMBERS OF TRIP COILS TO BE PROVIDED TO ENSURE POSITIVE TRIPPING OF INPUT BREAKER (Q1) THROUGH VFD.

2) CT & PT SUITABLE FOR VFD APPLICATION SHALL BE PROVIDED IN VFD FOR SYNCHRONOUS TRANSFER.

3) BYPASS BREAKER (Q3): MOTOR PROTECTION RELAY INCORPORATING OVER CURRENT, EARTH FAULT & DIFFERENTIAL PROTECTION (IN BYPASS MODE) TO BE PROVIDED BY PURCHASER (TPL).

4) IP CLASS: VFD : IP31 & LCS: IP55
DESIGN AMBIENT=45°C

5) ALL HT POWER CABLE, HT TERMINATION KIT, LT POWER CABLE, LT CONTROL, SCREENED CABLES ARE IN PURCHASER (TPL) SCOPE.

6) CABLES BETWEEN LCS AND VFD ARE IN PURCHASER (TPL) SCOPE.

7) * FINAL RATING DURING VFD DOCUMENTS APPROVAL STAGE.

8) CT RATIO PROVIDED BY PURCHASER IS 630/1A, 10VA, CL 1.0.

9) # 2 NOS. RJ-45 PORTS SHALL BE PROVIDED FOR SERIAL COMMUNICATION TO SAS.

B224-DCU-TPL-114-MR-DW-PR0001-0101	ELABORATED BLOCK DRAWING OF VFD (114-K-1001)
B224-DCU-TPL-114-MR-DS-PR0001-0100	DATASHEET OF VFD (114-K-1001)
B224-DCU-TPL-114-MR-DW-PR0001-0099	SCHEME OF VFD (114-K-1001)
B224-DCU-TPL-114-MR-GA-PR0001-0098	OUTLINE GA DRAWING OF VFD (114-K-1001)
DRAWING NO.	DRAWING TITLE

REFERENCE DOCUMENTS / DRAWINGS

DRG. CATEGORY: (USE TICK MARK) [R] [I] — EIL REVIEW/APPROVAL CODE: — VPTL NO.:
SCH. DATE OF SUBMISSION

DOCUMENT STATUS
STATEMENT OF SUB: [1st] [2nd] [3rd]
☐ FINAL FOR CODE-1 ☐ AS BUILT
ISSUED FOR
☐ ORDER ☐ INFORMATION
☐ ENQUIRY ☑ REVIEW
☐ CONSTRUCTION
SIGN: DATE:

☐ REVIEW CODE 1 – NO COMMENTS PROCEED WITH MANUFACTURE / FABRICATION/ CONSTRUCTION AS PER THE DOCUMENT.
☐ REVIEW CODE 2 – PROCEED WITH MANUFACTURE FABRICATION / CONSTRUCTION AS PER THE DOCUMENT.
☐ REVIEW CODE 3 – DOCUMENT DOES NOT CONFORM TO BASIC REQUIREMENTS AS MARKED. RESUBMIT FOR REVIEW.
☐ R – DOCUMENT IS RETAINED FOR RECORDS. PROCEED WITH MANUFACTURE / FABRICATION
☐ V–VOID
NAME DISCIPLINE SIGN. DATE

REV.	DESCRIPTION	DATE	DRN	CHECKED	APPROVED
3	REVISED IN LINE WITH COMMENTS	10.12.20	GD	LSL	LSL
2	REVISED IN LINE WITH COMMENTS	10.11.20	GD	LSL	LSL
1	REVISED IN LINE WITH COMMENTS	13.08.20	GD	LSL	LSL
0	ISSUED FOR REVIEW	06.07.20	GD	LSL	LSL

OWNER: HPCL–RAJASTHAN REFINERY LIMITED(HRRL)
RAJASTHAN REFINERY PROJECT PACHPADRA, RAJASTHAN
EPCC–04 PACKAGE–DELAYED COKER UNIT (DCU) AND UNSATURATED LPG TREATING UNIT

PMC : इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम) ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

LSTK CONTRACTOR: TATA PROJECTS LIMITED, MUMBAI

DETAILED ENGINEERING CENTER: AkerSolutions

VENDOR: BHARAT HEAVY ELECTRICALS LTD. HYDERABAD — VENDOR PO NO. — VENDOR DWG. NO. 1669–70–PR–VFD–01

DATE SCALE
DEPT: VFD
DRN BY: GD
CHK BY: LSL
APP BY: LSL

TITLE: SINGLE LINE DIAGRAM OF VFD FOR WET GAS COMPRESSOR (114–K–1001)

PROJECT: DRG. NO.: B224–DCU–TPL–114–MR–DW–PR0001–0097 SH. 01 REV. 03
PWO NO.:
CAD REVISE THIS DRG. USING CAD SYSTEM ONLY FILE:

AkerSolutions

☐ REVIEW CODE 1 – NO COMMENTS PROCEED WITH MANUFACTURE / FABRICATION/ CONSTRUCTION AS PER THE DOCUMENT.
☐ REVIEW CODE 2 – PROCEED WITH MANUFACTURE / FABRICATION / CONSTRUCTION AS PER COMMENTED DOCUMENT. REVISED DOCUMENT REQUIRED.
☐ REVIEW CODE 3 – DOCUMENT DOES NOT CONFORM TO BASIC REQUIREMENTS AS MARKED. RESUBMIT FOR REVIEW.
☐ R – DOCUMENT IS RETAINED FOR RECORDS. PROCEED WITH MANUFACTURE / FABRICATION
☐ V–VOID

DISCIPLINE SIGN DATE

THIS REVIEW / APPROVAL DOES NOT RELIEVE THE VENDOR / MANUFACTURER OF THE FULL RESPONSIBILITY AS TO DESIGN CORRECTNESS OF DIMENSIONS & COMPLIANCE WITHALL APPLICABLE REGULATIONS AND WITH THE REQUIREMENTS MADE IN PURCHASER SPECIFICATIONS.

PC–2023–037_R0

Project	PMC Services for Execution of Rajasthan Refinery Project (RRP)			**Client**	HRRL - REGD. OFFICE
Unit	Delayed Coker Unit	**Location**		**Job No.** B224	**Unit No.** 114

PURCHASER'S DATA

A.	**Site Conditions**		
1.	Maximum Ambient Temperature	°C	48.2
2.	Minimum Ambient Temperature	°C	3.4
3.	Design Ambient Temperature	°C	45
4.	Relative Humidity	%	100
5.	Altitude	mm	Less than 1000
6.	Environment		Humid Highly Corrosive
B.	**Technical particulars**		
1.	Motor Tag no.:		114-KM-1001
2.	Driven Equipment name:		Wet Gas Compressor
3.	Voltage:	kV	6.6 ± 10 %
4.	Phase:		Three
5.	Frequency:	Hz	50 ± 3 %
6.	Fault level:	kA	40
7.	Fault Duration:	sec.	0.25
8.	System Earthing:		Resistance Earthing
9.	Duty:		Continuous
10.	Method of starting:		V.S.D DOL
11.	Cable size:	mm²	3 Runs of 3Cx300 Sq.mm.
12.	Cable type:		Al. cond. XLPE insulated
13.	Temperature rise:	°C	80 °C (By RTD Method)
14.	Cooling:		CACA / IC611
15.	Insulation class:		F
16.	Temperature rise Limited to insulation class		B
17.	Hazardous area classification:		Zone 2, T3
18.	Dust classification		NA
19.	Gas group:		IIA / IIB
20.	Dust Group		NA
21.	Type of explosion protection:		Ex'P'
22.	Prestart purging for Ex(n) motor		Applicable (Ex'P' Motor)
23.	Type of ingress protection:		IP 55
24.	Reacceleration::		Yes
25.	Diff. protection CTs:		Yes , 3 Nos. in NTB (By Purchaser) ***R1***
26.	CT specs.:		**CORE WOUND TYPE CT** CT Ratio: 630/1A, Secondary Winding Resistance R_{ct} (max) at 75 °C≤ 5 Ω, Knee Point Voltage : $V_k \geq 252$ V, Excitation Current : $I_{mag} \leq 30$mA at V_k/2 Insulation Class: E or Better Material : Cast Resin BIL: 7.2kV/20kV /60kV$_p$, Freq.: 50 Hz Standard: IS-16227-1 2 , STC: 40kA /3 Sec (CTs are Not in BHEL scope) ***R2***
27.	Color shade:		632 as per IS 5
28.	Thermisters:		Not Required
29.	RTD:		Required
30.	BTD:		Required
31.	RTD/BTD monitoring device:		Compressor vendor BHEL, Hyderabad Scope ***R1***
32.	Applicable specification:		EIL spec. 6-51-0031 Rev 6

DRIVEN EQUIPMENT MANUFACTURER's DATA

1.	Suggested motor rating:	kW	5150 kW

Rev. No.	Date	Purpose	Prepared By	Reviewed By	Approved By
A	13-MAR-2019	ISSUED WITH TENDER	BANSAL VARUN	SAHU MANJIT KUMAR	SAHU MANJIT KUMAR

Project PMC Services for Execution of Rajasthan Refinery Project (RRP) **Client** HRRL - REGD. OFFICE

Unit Delayed Coker Unit **Location** **Job No.** B224 **Unit No.** 114

2.	Manufacturer:		BHEL Hyderabad
3.	Type of driver mounting:		Horizontal
4.	Driven equipment:		Wet Gas Compressor
5.	Shaft kW:	kW	4477
6.	kW at maximum load:	kW	4477
7.	Speed:	RPM	1496 RPM
8.	Rotation of eqpt. from coupling end:		Clockwise from Drive End
9.	Coupling type:		Flexible
10.	Torque required starting	mkg	439.95
11.	Torque required Maximum	mkg	2933
12.	GD2 of eqpt including flywheel	kgm□	NA
	excluding flywheel:	kgm□	6900
13.	Maximum thrust:	kg	NIL
14.	Pulsation rate:		NA
15.	Starting condition:		As per Compressor TS Curve

MOTOR MANUFACTURER's DATA

1.	Rating:	kW	5150
2.	Manufacturer:		BHEL Bhopal
3.	Frame designation:		1SB1908-4
4.	No. of poles:		4
5.	Full load speed:	RPM	1496
6.	Mounting:		Horizontal
7.	Full load torque (FLT):	mkg	3351
8.	Starting torque:	% of FLT	75
9.	Break down or pull out torque	% of FLT	175
10.	Full load current (FLC):	A	516
11.	Starting current at 100□	% of FLC	500 □ FLC (Incl. of Tolerane)
12.	Rotation viewed from coupling end:		CW (Looking from Motor DE)
13.	Starting time at 80□ □100□ voltage:	sec.	42 (□ 85□) □19 (□ 100□) (Min. Voltage–85□ RV)
14.	Locked rotor withstand time (cold□hot) at,		
	80□ voltage	sec.	44 □32 (Cold Hot withstand time □ 85□ Voltage) ***R2***
	100□ voltage:	sec.	30 □24
15.	Time (Te) for Increased Safety Motor at 100□ Voltage		NA
16.	Efficiency at 75□ □100□ Load:	%	96.6 □97.0
17.	Power factor at 75□ □100□ Loa		0.90 □0.90
18.	Heating□Cooling Time Const. (min.)	min	30□90
19.	Space heater - voltage power:		1000 Watts , 1Ph 240V AC ***R2***
20.	Moment of inertia, GD2:	kgm□	2070
21.	DE□NDE bearing type no.:		Sleeve bearings, DIN Standard 1 No DE (Size-22-□200) 1 No. NDE (22-□200)
22.	Type of lubrication:		FOLS (6.0 LPM □Per Brg., ISO VG 46)
23.	Type of main terminal box:		PSTB Type
24.	Type of neutral terminal b		Fabricated Terminal Box
25.	No. of Terminals		6 Nos.
26.	Weight of motor:	kg	25000 kg

Rev. No.	Date	Purpose	Prepared By	Reviewed By	Approved By
A	13-MAR-2019	ISSUED WITH TENDER	BANSAL VARUN	SAHU MANJIT KUMAR	SAHU MANJIT KUMAR

Project PMC Services for Execution of Rajasthan Refinery Project (RRP) **Client** HRRL - REGD. OFFICE

Unit Delayed Coker Unit **Location** **Job No.** B224 **Unit No.** 114

27.	Thermisters, quantity	no.	NA
	make: type:		NA
28.	RTD, quantity:	no.	12 Nos.
	make: type:		BHEL Approved Vendor, PT-100 3 Wire Simplex
29.	BTD, quantity	no.	2 No per Bearing
	make: type:		BHEL Approved Vendor, PT-100 3 Wire Duplex
30.	Shaft voltage:	V	NA (As NDE Bearing is insulated)
31.	Critical speed, 1st 2nd st	RPM	1990 9300
32.	Pressurization panel:		Yes
	make: type:		Make : M s Expo Type: Electro-Pneumatic
33.	Canopy:		No
34.	Fan rotation Design		Fixed

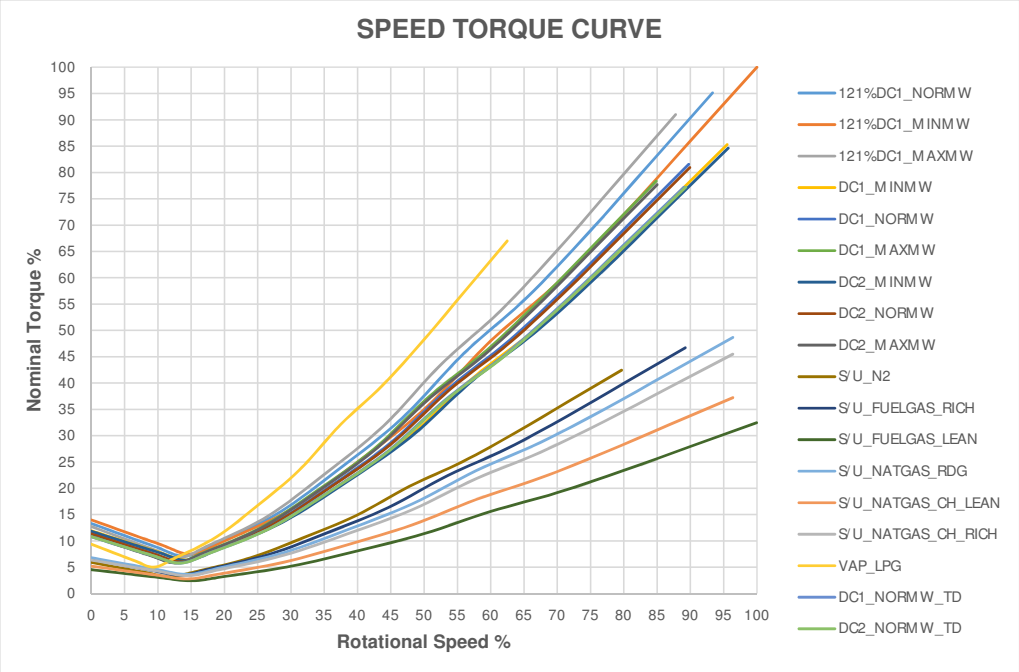
Eil Notes

1 Recommended list of maintenance spares for two years operation shall include the following as minimum: (a) Bearing DE NDE one set, (b) Terminal box coverwith screws, (c) Fan, (d) Terminal block
2 Thermistors, RTDs and BTDs are applicable for motors as per EIL Specification 6-51-0031.
3 Cable glands to be supplied with motors shall meet all requirements as pe IS IEC-60079.
~~4 HV motors starting current shall be limited to < 500 of FLC (Subject to IS tolerance) .~~
~~5 Starting time calculations shall be based on operating conditions specified on Material Requisition eg. open valve ccondition closed valve condition, at no load full load, as applicable.~~
4 HV motors starting current shall be limited to ≤500% of FLC (Incl. of IS tolerance). ***R1***
5 Starting time calculations shall be based on operating conditions during 121 DC1 MINMW start-up condition. ***R1***
6 Minimum no. of consecutive COLD HOT starts for motor shall be 2 and 1 respectively. ***R1***

Rev. No.	Date	Purpose	Prepared By	Reviewed By	Approved By
A	13-MAR-2019	ISSUED WITH TENDER	BANSAL VARUN	SAHU MANJIT KUMAR	SAHU MANJIT KUMAR

BHEL Maharatna Company	**STARTING TORQUE CURVE FOR CENTRIFUGAL COM PRESSOR**	**Sheet 1 of 2**

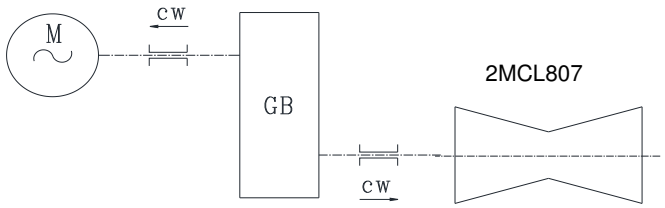
PROJECT : HRRL DCU
SERVICE : Wet Gas Compressor
CUSTOMER : M/s HRRL
CONSULTANT : M/s TPL
No. OF UNITS : 1



The motor is provided with VFD in order to realize different operating conditions as specified by the customer. These are indicated by the curves as shown above.

Motor Rating	5150 kW
Nominal Power	4477 kW
Motor Speed at Full Load	1485 rpm
Nominal Torque	2933 kgm
Static Torque	439.95 kgm
GD2 (Referred to Motor Speed)	6900 kgm2
Direction of Rotation seen from Coupling end (for Motor)	CW
Shaft end cylindrical diameter	220 mm #
No. of Keys on Shaft end	1
Speed Range %	60-105%
Connection for Hub on Shaft Cylindrical fit of H6 / m5	
Compressor Power is referred to low speed shaft of step up Gear Box	

ARRANGEMENT OF MACHINES



(#) Considered for coupling sizing. Motor group to check adequacy and confirm.

Please refer enquiry specification for all other technical details to finalize the motor design *(Refer sheet2 for DOL)*

STEAM TURBINES AND COM PRESSORS				Date	Dept. code
				11.06.2020	420
Format No.	**Prepared**	**Checked**	**Approved**	**Drawing No.**	**Rev**
CA0-1-034-00	KVS	NEMA	YVRL	4CM41600934	00

CASE DESCRIPTION

SL NO	DESCRIPTION	COMPR. POWER (KW)	COMPR. SPEED (RPM)
1	121% FLOW DC1 NOR MW	3986	7844
2	121% FLOW DC1 +NOR MW	3596	7377
3	121% FLOW DC1 -NOR MW	4477	8405
4	DESIGN CASE1 NOR MW	3294	7544
5	DESIGN CASE1 +NOR MW	3001	7133
6	DESIGN CASE1 -NOR MW	3654	8028
7	DESIGN CASE2 NOR MW	3275	7557
8	DESIGN CASE2 +NOR MW	2981	7145
9	DESIGN CASE2 -NOR MW	3631	8041
10	START UP NITROGEN	1546	6695
11	START UP FG RICH GAS	1883	7500
12	START UP FG LEAN GAS	1451	8400
13	START UP NG RDG CAIRN	2104	8100
14	START UP NG CHHARA LEAN LNG	1612	8100
15	START UP NG CHHARA RICH LNG	1967	8100
16	START UP VAPOURIZED LPG	1927	5251
17	DESIGN CASE1 TURNDOWN	3095	7482
18	DESIGN CASE2 TURNDOWN	3106	7507

DOL (VFD Bypass) :

During DOL, request to consider "121%DC1_MINMW" case curve only for motor sizing.

During starting time (DOL) load on compressor will be 150% (anti surge valves will be in open condition) for a period of 15 minutes. However, it will be after reaching Motor 100% speed.

उच्च वोल्टेज वैरीएबल फ्रीक्वेन्सी ड्राईव सिस्टम के लिए विनिर्देश

SPECIFICATION FOR HV VARIABLE FREQUENCY DRIVE SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	16.10.14	REVISED AND ISSUED AS STANDARD SPECIFICATION	MK/SA	HK	BRB	SC
1	24.04.09	REVISED AND ISSUED AS STANDARD SPECIFICATION	AM	SG	JMS	ND
0	25.03.03	ISSUED AS STANDARD SPECIFICATION	SSM	AAN	VPS	SKG

Abbreviations:

AC	:	Alternating Current
BIS	:	Bureau of Indian Standards
BS	:	British Standard
CEA	:	Central Electricity Authority
CFL	:	Compact Fluorescent Lamp
CIMFR	:	Central Institute of Mining and Fuel Research (formerly CMRI)
CRCA	:	Cold Rolled Cold Annealed
CW	:	Cooling Water
DC	:	Direct Current
DCS	:	Distributed Control System
DOL	:	Direct On Line
ECS	:	Electrical Control System
EM	:	Electromagnetic
HV	:	High Voltage
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IEGT	:	Injection Enhanced Gate Transistors
IGBT	:	Insulated Gate Bipolar Transistor
IGCT	:	Insulated Gate Commutated Transistor
I/O	:	Input/Output
IP	:	Ingress Protection
IS	:	Indian Standard
LED	:	Light Emitting Diode
mA	:	Milliampere
MCB	:	Miniature Circuit Breaker
MTBF	:	Mean Time Between Failure
MTTR	:	Mean Time to Repair
NEMA	:	National Electrical Manufacturer's Association
PLC	:	Programmable Logic Controller
PO	:	Purchase Order
PVC	:	Poly Vinyl Chloride
SGCT	:	Silicon Gate Commutated Transistor
THD	:	Total Harmonic Distortion
V_{BO}	:	Break Over Voltage
VDE	:	Verband Deutscher Electrotechniker
VFD	:	Variable Frequency Drive

Electrical Standards Committee

Convener : Mr. B.R.Bhogal

Members : Ms. Sumita Anand
Mr. Parag Gupta
Mr. M.K.Sahu
Mr. A.K. Chaudhary (Inspection)
Ms. N.P. Guha (Projects)

CONTENTS

1.0 SCOPE

1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of High Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer (if required), drive output transformer (unless specifically agreed, drive output transformer shall not be provided), DC link reactor with associated auxiliaries, harmonic filters (if required) and field mounted local motor control panel.

1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. 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, motor cable selection and motor sizing/selection.

1.3 This specification applies to drive systems having converter input voltage above 1000 V AC and up to and including 11000V AC.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the latest editions of the following standards unless specified otherwise:

IS:325	Three-phase Induction Motors
IS:3700	Essential Ratings and Characteristics of Semiconductor Devices
IS:3715	Letter symbols for semi-conducting devices
IS:4411	Code of designation of semi-conducting devices
IS:5001	Guide for preparation of drawings of semiconductor devices and Integrated Circuits
IS:5469	Code of practice for the use of semiconductor Junction Devices
IS:8789	Values of Performance characteristics for Three Phase induction motor
IS:12615	Energy Efficient Induction Motors – Three Phase Squirrel Cage
IS:12729	Common specification for High-Voltage Switchgear and Controlgear standards
IS:14901	Semi-conductor devices- Discrete devices & Integrated Circuits
IS:15880	Three Phase Cage Induction motors when fed from IGBT Converters- Application Guide
IEC:60146-1-3	Semiconductor Convertors general requirements and line commutated convertors-Transformer & reactors
IEC:61800	Adjustable speed electrical power drive systems
IEEE:519	Recommended Practices and requirements for Harmonics Control in Electrical Power Systems

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of CEA Regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents, the most stringent one shall prevail. However, owner's decision in this regard shall be final and binding.

3.0 SITE CONDITIONS

3.1 The drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 40^{O}C and an altitude not exceeding 1000 metres above mean sea level shall be considered.

3.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet. Transformer installation (outdoor/ indoor) shall be as indicated in datasheet. Motor shall be installed outdoors in safe or hazardous area as specified in datasheet.

3.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

4.0 GENERAL REQUIREMENTS

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

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection / sizing of offered variable frequency drive system.

5.0 TECHNICAL REQUIREMENT

5.1 Performance Requirement

5.1.1 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. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of ±10% and frequency variation of ±3%. 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.

5.1.3 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 or specified in the data sheet:

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 speed increases

d. Any other as specified in data sheet

5.1.4 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 adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 10-100 % unless otherwise specified in data sheet with speed set accuracy of ±1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.

5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc. The studies shall highlight but not be limited to maximum load current, expected resonant frequencies, need of harmonic filters, sequence of switching of filters, voltage wave form, rating of equipments/ feeder for feeding filters from owner's switchgear etc.

5.1.8 Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications 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 load demands exceed the current limit for more than 1 minute, the drive shall shutdown to prevent over heating of the motor and damage to the drive.

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

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

5.1.11 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.

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

5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting/ maintenance.

5.1.14 Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value.. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached EIL specification for High Voltage Motors.

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

5.2.6 The drive motor shall be speed controlled corresponding to 4-20 mA or 0-10 V reference input signal. Unless otherwise specified, upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

a) With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (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 switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

c) Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above. (For local control station, also refer Cl. 5.5.7 below).

5.2.8 The required provision for the interface with remote PLC/DCS located at control room shall be either through hardwired connection (with potential free contacts and transducers as described elsewhere in this specification) or through serial communication link as defined in the datasheet.

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.

5.2.10 The closed loop control feed back for the drive system having out put transformer shall be tapped from the secondary side of the output transformer.

5.3 Panel Construction

5.3.1 The panel shall include suitable semi conducting power devices (Diodes/IGBT/IGCT/ IEGT/SGCT) modules with protective devices, reactors (if required) , filters (if required), control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of relevant standards.

5.3.2 Upstream breaker `ON/OFF/TRIP' indications and remote breaker closing and trip push buttons shall be provided on the front door.

5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the up stream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 1.6 mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm^2 and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600mm clear from bottom of the cable gland plate.

5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.

5.3.7 All the switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with illuminating lamp/11 W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.

5.3.9 Copper earth bus of min. 30x6 sq.mm. upto short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to owner'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 if required shall be provided.

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

5.3.11 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 or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm^2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm^2 size for control fuse rating above 16 A for electrical circuits and 0.5mm^2 for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.

5.3.13 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.

5.3.14 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.

5.3.15 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.

5.3.16 Acrylic type transparent insulating material shall be used for covering live components.

5.3.17 Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.

5.3.18 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

5.4 Cooling

5.4.1 The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However, it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, modular cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.

5.4.2 For water-cooled drives, entire cooling system including but not limited to heat exchanger, flow and pressure meters and pumps shall be in vendor's scope. The system shall be provided with closed circuit water cooling system, requiring only make up water required for topping up. The cooling water pumps, in case provided, shall have 100% redundancy. Water quality/characteristics shall be as defined in the data sheet and selected cooling water system components/material shall be suitable for the same. Adequate safety measures shall be incorporated in water cooled drives such that no leakage is there which results in malfunctioning of electronic devices. Proper segregation between water cooling system and other equipment shall be provided. It is preferred that cooling cabinet panel shall be separated from the main panels.

5.4.3 Necessary starters shall be provided within the VFD panels for the Ventilation fans, Cooling Water circulation pumps, any other auxiliary motor etc. The system provided shall be interfaced with drive starting and shutdown so that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., are incorporated in the overall sequence logic.

5.4.4 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the latest revision of EIL's Specification /data sheet for High Voltage Induction / Synchronous Motor, in addition to the following requirements:

a. The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.

b. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c. The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.

d. The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.

e. Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.

f. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.

g. The motor insulation shall be designed to accept the applied voltage waveform, within the V_{peak} and dv/dt limits as per IEC-61800-4 and necessary co-ordination between the VFD manufacturer & motor manufacturer w.r.t. incorporation of VFD output parameter in the design of motor shall be carried out.

h. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

i. Motors shall be provided with Resistance Temperature Detectors (RTDs).

5.5.2 **Converter Transformer/ Output transformer (if specifically agreed by Purchaser)**

a. The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the drive system panel unless specified otherwise in the datasheet. Offered transformer shall be as per enclosed EIL Specifications/data sheet.

b. The impedances of converter input transformers with more than one secondary windings for 12/18/24/36 pulse systems shall be selected to ensure equal load/current sharing between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

c. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

5.5.3 **Power Converter**

a. 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. Power converter shall be fast switching, most efficient and low loss type.

b. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.

c. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.

d. 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 entire speed range.

e. All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.

f. 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.

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

h. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

i. Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories to make system suitable for a distance of 350m unless otherwise specified in the data sheet.

5.5.4 **DC Link Reactor**

a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.

b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.

c. 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 limits.

5.5.5 **Output Filter**

VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type.

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

5.5.6 **Bypass Feature**

a. Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of VFD system along with bypass feeder and output side isolator/breaker provided by Purchaser shall be provided in VFD system.

b. Bypass starter shall be in separate compartment and switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended independently. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 **Local Motor Control Station**

a. The local motor control station, to be installed in the field near the motor shall conform to the attached EIL specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.

b. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass mode full load and starting currents as well as the VFD mode drive current.

5.6 Protection, Control, Metering, Indication and Annunciation

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

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

5.6.3 **Operator Control Panel**

a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.

b. 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 the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.

c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.

d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.

e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.6.4 **Protective Features**

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

i. Incoming line surge protection

ii. Under / Over voltage protection

iii. Phase loss protection.

iv. Programmable over current protection and under load protection.

v. Inverter Fault.

vi. Over frequency/Over speed of motor

vii. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).

viii. Over temperature of equipment.

ix. Specific motor protection, including motor winding, bearing temperatures, over-current, overload, negative phase sequence and earth fault protections etc.

x. System earth fault protection.

xi. Excitation system protection for synchronous motor

xii. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor

xiii. Additional protection, if any for the drive system

5.6.5 **Control**

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

i. Start/Stop

ii. Speed control (Raise/Lower)

iii. Forward/Reverse (if specified)

iv. Auto/Manual /Test mode

v. Local/Remote

vi. Emergency stop

vii. Start/Stop for bypass starter (where specified)

viii. Trip-Remote Breaker

ix. Excitation control system for synchronous motors

x. Sequential switching of filters

5.6.6 **Indications**

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

i. Motor running

ii. Motor stopped

iii. VFD System Fault

iv. System ready to start

v. AC mains ON

vi. Motor over speed

vii. Rectifier output 'ON'

viii. Motor zero speed

ix. Remote breaker trip

x. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.

Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.6.7 **Metering**

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

i. Output voltage

ii. Output current-VFD mode/ Bypass mode

iii Output frequency

iv Drive thermal state

v. Motor speed

vi. Motor energy meter

vii. Hour Run

viii. Voltage and current meter for excitation system of synchronous motor

ix. KVAR, power factor meter for synchronous motors

x. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

5.6.8 **Audio-visual Annunciations**

a. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, out put transformer etc.

b. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

c. Audio-visual window annunciations shall be provided on the front of the panel. All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per vendor standards. These annunciations can be part of operator console panel or separately mounted type.

d. Vendor shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following.

i. Rectifier fuse failure/Drive fault

ii. Main AC failure

iii. Inverter fuse failure/Drive fault

iv. Inverter overload

v. Inverter high temperature/Drive fault

vi. Cooling system failure

vii. Motor failed to start/Drive fault

viii. Transformer failure

ix. Excitation system failure for synchronous motor

x. Battery monitoring healthiness

xi. Communication and measurement system unhealthy

xii. Motor temperature high

xiii. Harmonic filters monitoring

All drive internal faults will be annunciated as drive fault.

Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminal block for owner's use for remote alarm and monitoring.

5.7 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-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle 11W CFL lamps, indicating lamps, digital meters (Ammeter, Speedometer) etc. shall operate on 240 volts single phase AC supply provided by purchaser.

All control circuit shall operate at maximum voltage of 240V AC or 220V DC unless otherwise specified in the datasheet.

Vendor shall include supply of all control transformers, protective devices, associated accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

5.9 Reliability Features

The expected lifetime of the drive system shall be min. 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.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

- Modular construction
- All components shall be easily accessible.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the drive shall be subject to inspection by EIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of EIL/ Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the ITP for HV variable frequency drive 6-81-1050 as per IEC 61800-2. However, combined test for VFD and motor at vendor's works shall be carried out if specified in the datasheet.

6.4 Additional tests on switchgears and transformers shall be carried out based on the requirement defined in the EIL's specification of respective equipment.

6.5 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFR/ BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

8.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

शुष्क किस्म के डिस्ट्रीब्यूशन ट्रांसफार्मर के लिए विनिर्देश

SPECIFICATION FOR DRY TYPE DISTRIBUTION TRANSFORMERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	23.11.16	REVISED AND REISSUED AS STANDARD SPECIFICATION	NT	SA	BRB	RN
4	11.04.11	REVISED AND REISSUED AS STANDARD SPECIFICATION	MK	SA	UAP	DM
3	21.03.11	REVISED AND REISSUED AS STANDARD SPECIFICATION	NT	SA	UAP	DM
2	20.09.05	REVISED AND REISSUED	ND	AKT	AAN	VJN
1	08.11.01	REVISED AND REISSUED	NS	AAN	VPS	MRR

Abbreviations:

BIS	:	Bureau of Indian Standards
BS	:	British Standards
CEA	:	Central Electricity Authority
CT	:	Current Transformer
GI	:	Galvanised Iron
HV	:	High Voltage
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
KVA	:	Kilo Volt Amperes
MV	:	Medium Voltage
NEMA	:	National Electrical Manufacturers Association
PVC	:	Poly Vinyl Chloride
SWG	:	Standard Wire Gauge
VDE	:	Verband Der Electro technik and information Stechnik
51G	:	Back up Earth Fault Protection Relay
64R	:	Restricted Earth Fault Protection Relay

Electrical Standards Committee

Convener: Mr. B.R. Bhogal

Members: Ms. Sumita Anand
Mr. Parag Gupta
Mr. M.K. Sahu
Ms. N.S. Bhattacharya
Mr. Saeed Akhtar (Inspection)
Ms. N.P. Guha (Projects)

CONTENTS

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture, testing, packing and supply of cast resin / resin impregnated dry type distribution transformers.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified.

IS: 5	:	Colours for ready mixed paints and enamels
IS: 1271	:	Thermal evaluation and classification of electrical insulation
IS: 2705	:	Current transformers
IS: 10028	:	Code of practice for selection, installation and maintenance of transformers
IS: 11171	:	Dry type power transformers
IS/IEC: 60529	:	Degrees of Protection Provided by Enclosures (IP Code)

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of the CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent one shall prevail. However Owner's / EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

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

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

Transformer shall be suitable for installation and satisfactory operation in tropical, humid and corrosive atmospheres found in refineries, Petrochemical and Fertiliser Plants or as specified in the Material Requisition / Tender . The transformer shall be designed to operate under site conditions as specified in data sheet. If not specifically mentioned therein, design ambient temperature of 40°C and altitude not exceeding 1000m above MSL shall be considered.

5.0 CONSTRUCTION

5.1 The transformers shall have core type construction. The core shall be assembled out of low-loss, nonageing, high permeability cold rolled grain oriented steel laminations.

5.2 The windings shall be of high-grade electrolytic copper. The insulation system for cast resin transformers shall comprise of windings cast under vacuum, free of voids in a homogenous uniform laminate of epoxy resin/ polyester resin. The totally assembled core and coil assembly, for resin impregnated transformers, shall be vacuum pressure impregnated to effectively make it impermeable to moisture, dirt, salt, air and other industrial contaminants.

5.3 The entire core assembly shall be covered with a resin-based lacquer for corrosion protection.

5.4 Lifting lugs shall be provided for core and winding assemblies.

5.5 The HV and MV windings shall have class 'F' or better insulation. The temperature rise of windings under continuous full load shall not exceed the maximum allowable temperature for the appropriate class of insulation as per IS 11171, above the design temperature specified in the data sheet.

5.6 The insulation material used shall be non-hygroscopic, non- inflammable and self-extinguishing if ignited by direct flame or arc. No toxic or harmful gases shall form during heating and /or burning. The insulation materials shall be sufficiently resistant to ageing.

5.7 The transformers shall be capable of withstanding the thermal and mechanical effects of a dead short circuit on any or all winding terminals with full voltage maintained on other windings as per IS. The transformers shall sustain a symmetrical short circuit on secondary terminals for 2 seconds without damage or impairment.

5.8 Each limb shall have two solid state winding temperature monitoring elements to initiate an alarm and trip for winding over temperature.

5.9 The transformers for Indoor & outdoor location shall have minimum degree of protection as IP 23 & IP 43 respectively. However the marshalling box, cable termination box, bus-duct termination chamber etc. shall have a degree of protection not less than IP-55.

5.10 All fasteners and bolts shall be galvanised.

5.11 The transformers shall be spray-painted or powder coated with epoxy paint. Colour shade of final paint shall be as specified in the data sheet.

6.0 TERMINAL AND MARSHALLING BOX

6.1 Windings shall be brought out on suitable nickel-plated copper terminals for cable termination. HV side termination shall be from the bottom. Suitable disconnection chambers shall be provided to permit the transformer to be removed without disconnecting the cable termination. The MV side termination shall be by bus-duct or cable as defined in datasheet / job specification.

6.2 The high voltage and medium voltage cable termination arrangement shall be complete with cable box and bolted type undrilled cable gland plates. Non-magnetic gland plate shall be provided for single core cables.

6.3 Primary cable box shall be able to withstand specified primary system fault level for 0.2 secs.

6.4 Terminal chamber for busduct termination shall have a gasketed cover plate, bolted to it. Separate inspection covers shall be provided to facilitate connection and inspection.

6.5 All protection, alarm and indication devices and neutral CTs shall be wired by means of PVC insulated cables upto the marshalling box. There shall be two gland plates, one for internal wiring to the marshalling box from various devices which shall be glanded and pre-wired, while the second gland plate shall be removable and undrilled for glanding outgoing cables.

6.6 One neutral terminal inside the cable box/ MV bus-duct connection chamber and a separate neutral terminal outside shall be provided for earthing of transformer winding neutral on the secondary side. The neutral terminal shall be complete with connector block assembly for easy termination of GI earth strip/cable.

6.7 The neutral CT shall be mounted as below:-

a) CT for 51G shall be located in the earth path after bifurcation of neutral.
b) CT for 64 R can be located before bifurcation of neutral.

6.8 Two earthing terminals shall be provided on the transformer frame for transformer body earthing. Suitable lifting arrangement shall be provided in the transformer frame. The transformer shall be supported on flat rollers.

7.0 COOLING

Type of Cooling shall be in accordance with the datasheet.

8.0 TAPPINGS AND CONTROLS

Primary off-circuit rotary type tap changer shall be provided and shall have a range as specified in the data sheet. Tap changing arrangement through links is not acceptable. Under conditions of external short circuit, the tap changing device shall be capable of carrying the same current as the windings.

9.0 ACCESSORIES

9.1 Accessories as specified on data sheet shall be included in the scope of supply. All protective, alarm and indicating devices shall have minimum 1 no. potential free contact each for alarm and trip. All transformers must be provided with at least the following:

- Bi-directional flat rollers
- Rating and terminal marking plate
- Marshalling box
- Lifting hooks and jacking pads, towing holes
- Earthing terminals
- Neutral CT (as per data sheet)
- Off-circuit tap changer
- Temperature monitoring system (For rating 500KVA & above)

9.2 Temperature monitoring system shall be supplied with temperature sensors fitted in each limb. Temperature monitoring system shall initiate alarm and trip for winding over temperature. Alarm and trip temperatures shall be site settable. The monitoring system shall also have an indicating device.

10.0 NOISE LEVEL

The average audible sound level for the transformers at a distance of 30 cm shall be as below:

KVA	AVERAGE SOUND LEVEL (DECIBEL)
0-50	50
51-150	55
151-300	58
301-500	60
501-700	62
701-1000	64
1001-1500	65
1501-2000	66
2001-3000	68
3001-4000	70
4001-5000	71

11.0 INSPECTION AND TESTING

EIL / owner's representatives shall be given free access to enter the plant and inspect the equipment at any time during fabrication. However, 4 weeks advance notice shall be given by vendor to witness the final tests.
For testing requirements, refer Inspection & Test Plan doc. no. 6-81-1044. All testing shall be carried out at manufacturer's works under his care and expense.

12.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation i.e. by ship/ rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in the crates/ cases to prevent damage to the finish. Crates / cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owner's particulars', 'P.O. numbers' etc., shall be clearly marked on the package together with other tag numbers etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

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SPECIFICATION FOR FLAMEPROOF CONTROL STATIONS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	24.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR
1	19.08.96	REVISED AND ISSUED AS STANDARD SPECIFICATION	AP	VPS	SG	AS

Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
BS	British Standards
CEA	Central Electricity Authority
CIMFR	Central Institute of Mines and Fuel Research (formerly CMRI)
CT	Current Transformer
DGMS	Directorate General of Mines Safety
ERTL	Electronics Regional Test Laboratory
FM	Factory Mutual Research Corporation
GI	Galvanised Iron
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Ingress Protection
IS	Indian Standards
LCIE	Laboratoire Central des Industries Electriques
LED	Light Emitting Diodes
NEMA	National Electrical Manufacturers Association
PESO	Petroleum and Explosives Safety Organisation
PVC	Poly Vinyl Chloride
SWG	Standard Wire Gauge
VDE	Verband Der Electrotechnik, Elecktronik und Information Stechnik
UL	Underwriters Laboratory

Electrical Standards Committee

Convenor: Mr. B. R. Bhogal

Members: Ms. Sumita Anand
Mr. Parag Gupta
Mr. M. K. Sahu
Ms. N. S. Bhattacharya
Mr. Saeed Akhtar (Inspection)
Ms. N. P. Guha (Projects)

CONTENTS

1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of flameproof control stations and accessories suitable for installation in locations handling flammable liquids and gases / vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	: Colours for ready mixed paints and enamels.
IS-1248	: Direct acting indicating analogue measuring instruments and their accessories.
IS / IEC 60079-0	: Electrical apparatus for explosive gas atmospheres (General Requirements).
IS / IEC 60079-1	: Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d").
IS / IEC 60079-7	: Electrical apparatus for explosive gas atmospheres (Equipment Protection by Increased Safety "e").
IS / IEC 60529	: Degree of protection provided by enclosures (IP Code).
IS / IEC 60947	: LV switchgear and control gear.

2.2 In case of imported equipment, standards followed in the country of origin shall be applicable, if these standards are equivalent or more stringent than the applicable Indian Standards.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

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

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries, petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 CERTIFICATION

The equipment shall have test certificates issued by recognised independent test house (CIMFR/ ERTL/ Baseefa/ LCIE/ UL/ FM or equivalent). All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authorities.

6.0 TECHNICAL REQUIREMENTS

6.1 Construction

6.1.1 The enclosures of the control stations shall be made of cast light metal alloy.

6.1.2 The control stations shall be suitable for use in outdoor open locations and shall have IP-55 degree of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 14 SWG (2mm) galvanised sheet steel. The canopy shall be suitable for providing protection against rain from top and two sides.

6.1.3 The control stations shall be provided with gaskets made of non-inflammable and self-extinguishing material.

6.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting cycle. After preparation of under surface, the equipment shall be painted with two coats of epoxy based final paint with colour shade as below:

- Flame proof (Gas group IIA/ IIB) : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof (Gas group IIC) : Light yellow shade 355 of IS-5/ RAL-1012

All unpainted steel parts shall be suitably treated to prevent rust formation. If these parts are moving elements then these shall be greased.

6.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

6.1.6 All accessories like nuts, bolts, washers etc. and operating shaft of pushbuttons, switches etc. shall be made of stainless steel SS-304.

6.1.7 The control stations shall be provided with two earthing studs with lugs on the external surface of the enclosures suitable for termination of 8 SWG GI wire.

6.1.8 The control station shall be provided with bottom cable entries. Required number of flameproof double compression nickel plated brass cable glands and flameproof nickel plated brass sealing plugs shall be provided.

6.1.9 The control stations shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

6.1.10 A nameplate indicating Tag Number shall be provided on each control station. Separate nameplate shall also be provided to indicate the details of testing agency (CIMFR or equivalent), test certificate reference, statutory approval agency (PESO / DGMS) and reference, BIS license number, applicable gas group etc. The nameplates shall be engraved type and permanently fixed on the equipment. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the name plate.

6.1.11 All flameproof control station shall be suitable for 240V AC as well as 110V/220V DC control supply.

6.2 Component Specification

6.2.1 Push buttons for START and STOP shall be of GREEN and RED colour respectively. Each push button shall have two NO and two NC contacts. The STOP push button shall be mushroom type with stay put feature and lockable in pressed position.

6.2.2 All control switches shall be provided with a pistol grip handle. Circuit breaker control switch, wherever specified, shall have three positions (START - NEUTRAL - STOP) with spring return to neutral from START position and stay put in STOP position. All control/ selector switches shall have minimum two poles for each position. Each position of switch shall be indelibly marked on the control station. Exact configuration of selector switch (LOCAL-OFF-REMOTE or AUTO-OFF-MANUAL) shall be as per datasheet / MR requirement.

6.2.3 All ammeters shall be of moving iron type having an accuracy class of 3 and suitable for 1 Ampere CT secondary. Minimum size of ammeter shall be either 72mm x 72 mm or 65 mm diameter. 80% of the scale length shall cover 100% of the CT primary current uniformly and the balance 20% of the scale shall cover 100-800% of the CT primary. A red mark corresponding to the full load current of the motor shall be provided on the ammeter dial. The ammeter front glass shall be toughened.

6.2.4 Indicating lamp(s) wherever provided shall be clustered LED type (with minimum 3 numbers LEDs, preferably connected in parallel), mounted inside an enclosure of minimum diameter of 15mm.

6.3 Terminals & Wiring

6.3.1 The control stations shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Each terminal for external cable connection shall be suitable for termination of 2.5 mm^2 solid copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

6.3.2 All internal wiring shall employ 1.5 mm^2, 660V grade, FR type, PVC insulated copper conductor wires.

6.3.3 For flameproof equipments, terminal box can be provided in 'Exe' or 'Exd' execution.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorized by the Owner, if specified/ agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/acceptance tests shall be carried out at manufacturer's works under his care & expense.

7.2 Type test certificates from CIMFR or equivalent test house, applicable PESO/DGMS approval certificates, BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The certificates and BIS license must be valid at the time of despatch.

7.3 Test certificates of bought out components shall be shown to the inspection agency on demand during inspection.

7.4 All equipments shall be subjected to various routine / acceptance tests as per Inspection & Test plan no. 6-81-1006.

8.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity',

'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

Part-I (Data to be filled in by purchaser)

1.	Applicable standards		:	EIL spec. 6-51-0050
2.	Rated output capacity (KW)		:	*
3.	Rated Output voltage		:	*
4.	Motor Details			
	a)	Motor tag no.	:	*
	b)	Type of motor	:	*
	c)	KW rating	:	*
	d)	Starting condition	:	*
	e)	Frequency range	:	*
	f)	Voltage range	:	*
	g)	Full load current	:	*
	h)	Full load PF		
		- pf at lowest KW	:	*
		- pf at Highest KW	:	*
	i)	Starting current	:	*
	j)	Load torque details	:	*(As per Cl. 5.1.3 of 6-51-0050)
5.	**SITE CONDITIONS:**			
	a)	Ambient temperature	:	Max. 48.2° C / Min.3.4° C
	b)	Design temperature	:	45° C
	c)	Altitude	:	Less than 1000M
	d)	Installation	:	Indoor
	e)	Location	:	Substation
6.	**INPUT POWER SUPPLY SYSTEM CONDITIONS**			
	a)	No. of phases	:	3
	b)	AC input voltage	:	6.6kV
	c)	Voltage fluctuation	:	± 10%
	d)	Rated frequency	:	50 Hz
	e)	Frequency fluctuation	:	± 3%
	f)	System fault level	:	40kA
7.	**SYSTEM REQUIREMENTS**			
	a)	Speed range required	:	As per process requirement
	b)	Adjustment of speed	:	Auto (from DCS) & Manual (from LCS – As per process requirement)
	c)	Speed Reference by measurement of the stator voltage frequency through voltage transformer	:	*
	d)	Reference Signal	:	4 - 20 mA (from DCS).
	e)	By pass Breaker	:	In Purchaser scope
	f)	Acceleration time	:	*
		Deceleration time	:	*
	i)	Fault diagnostic	:	Required
	j)	Braking	:	
	k)	Regeneration	:	

l)	Cable length between Swbd. and VFD.	:	*	
n)	Cable length between VFD and Motor	:	*	
o)	Cable length between VFD and DCS	:	*	
p)	Separate PE Conductor between VFD & Motor	:	Required / Not Required	
q)	Communication facility with data concentrator on open protocol	:	Required	

*** - Data to be provided by vendor/equipment supplier**

PART-II (to be filled in by vendor)

1.	Make	:		
2.	Model No.	:		
3.	Rating	:		
4.	Applicable code/standards	:		
5.	Speed range	:		
6.	Speed reference	:		
7.	Input power supply ratings			
	a) Voltage	:	±	%
	b) Frequency	:	±	%
8.	Overload capability			
	a) 125%	:	minutes	
	b) 150%	:	secs.	
	c) Inrush current 250% I_n for	:	secs.	
9.	Overall efficiency at			
	a) 100% load	:		
	b) 75% load	:		
	c) 50% load	:		
	d) 25% load	:		
10.	Overall power factor at			
	a) 100% load	:		
	b) 75% load	:		
	c) 50% load	:		
	d) 25% load	:		
11.	AC Output			
	a) Output voltage range	:		
	b) Voltage accuracy	:		
	c) Frequency range	:		
	d) Frequency accuracy	:		
12.	Output short circuit capability and duration	:		
13.	Deration of motor at			
	a) Maximum speed	:		
	b) Minimum speed	:		
14.	**Rectifier/Inverter**			
	a) Make	:		
	b) Type/Model No.	:		
	c) Diodes/GTOs configuration	:		
	d) Total No. of Diodes/GTOs	:		
	e) Cooling system			
	- Type	:		
	- Redundancy in cooling Units	:		

	f)	Type of feedback for speed control	:	
15.	**DC Reactor**			
	a)	Make	:	
	b)	Type	:	
	c)	Rating	:	
	d)	Inductance of the reactor	:	
	e)	Air Core/Iron Core	:	
16.	**Output Filter**			
	a)	Make	:	
	b)	Type / Model No.	:	
	c)	Rating	:	
	d)	Rated Voltage	:	
17.	**Output Power Isolating Device**			
	a)	Make	:	
	b)	Type	:	
	c)	Model No.	:	
	d)	Cont. Current Rating	:	
	e)	Short Circuit Rating	:	
	f)	Rated Voltage	:	
	g)	Applicable Standard	:	
	h)	Panel details		
		- Overall Length	:	
		- Height	:	
		- Depth	:	
		- Degree of protection	:	
18.	**VFD PANEL DETAILS**			
	a)	Overall Length	:	
	b)	Height	:	
	c)	Depth	:	
	d)	Weight of cubicle	:	
		(Dimensional details of all panels shall be furnished)		
	e)	Degree of protection for enclosure.	:	
	f)	Paint shade	:	
	g)	Heat output of Panel	:	
	h)	Type of cooling	:	
19.	**Auxiliary Power Requirement:**			
	a)	KW	:	
	b)	Voltage	:	
20.	LCS/LCP required as per spec		:	Yes
21.	Requirement of earthing cable between motor & drive		:	
22.	Address of Manufacturing Location		:	
23.	Address of Shop Testing Location		:	
24.	Since when the proposed type of semiconducting power devices are being used in the offered drive model		:	
25.	List of equipments / Components to be sourced from India		:	

Project PMC Services for Execution of Rajasthan Refinery Project (RRP) **Client** HRRL - REGD. OFFICE

Unit Delayed Coker Unit **Location** **Job No.** B224 **Unit No.** 114

PURCHASER'S DATA

A.	**Site Conditions**		
1.	Maximum Ambient Temperature	°C	48.2
2.	Minimum Ambient Temperature	°C	3.4
3.	Design Ambient Temperature	°C	45
4.	Relative Humidity	%	100
5.	Altitude Above MSL	m	Less than 1000
6.	Environment		Humid & Highly Corrosive
B.	**Technical particulars**		
1.	Tag no.		
2.	Duty		Continuous
3.	Service		~~Lighting~~
4.	No. of windings		~~Two~~
5.	Type of cooling		AN
6.	Rated MVA		
7.	Rated voltage		
	HV winding	kV	~~0.415~~
	LV winding	kV	~~0.415~~
8.	System earthing		
	HV side		~~Solidly Earthed~~
	LV side		~~Solidly Earthed~~
9.	Rated frequency	Hz	50 +/- 3 %
10.	No. of phases		Three
11.	Fault level on HV side	kA	
12.	Connection		
	HV side		~~Delta~~
	LV side		~~Star~~
13.	Vector group		~~Dyn11~~
14	Impedance at max. MVA	%	~~Min. as per IS~~
15.	Insulation class		H
16.	Insulation level		
	P.f withstand		
	HV winding	kV	~~As per IS~~
	LV winding	kV	~~As per IS~~
	Impulse withstand		
	HV winding	kVp	~~As per IS~~
	LV winding	kVp	~~As per IS~~
17.	Winding insulation type		Uniform
18.	Creepage distance		
	Prim. winding		
	total		As per IS
	protected		As per IS
	LV winding		
	total		As per IS
	protected		As per IS
19.	Tab changer		

Rev. No.	Date	Purpose	Prepared By	Reviewed By	Approved By
A	13-MAR-2019	ISSUED WITH TENDER	BANSAL VARUN	SAHU MANJIT KUMAR	SAHU MANJIT KUMAR

Project PMC Services for Execution of Rajasthan Refinery Project (RRP) **Client** HRRL - REGD. OFFICE

Unit Delayed Coker Unit **Location** **Job No.** B224 **Unit No.** 114

	Location		Primary Winding
	Type		Offcircuit
	Range	%	± ~~10~~
	No. of steps		~~As per specification~~
20.	Normal load	%	~~30-40~~
21.	Max efficiency at 0.8 p.f		By vendor
22.	Load at which max eff. occurs	% MVA	~~40~~
23.	Power flow		Unidirectional
24.	Terminal location		
	HV side		Larger side
	LV w.r.t HV	°	~~90~~
25.	Terminal connection		
	HV side		Cable box
	LV side		
26.	Cable Size/Type		
	HV side		
	LV side		
27.	Neutral CT specification		
	51G		Not Required
	64R		Not Required
	Vk	A	
	Im at Vk/2	mA	
	RCT	ohm	
28.	Installation		Indoor
29.	Painting & colour		RAL-7032
30.	AC Auxiliary voltage	V	240 +/- 10 % SPN
31.	DC Auxiliary voltage	V	
32.	Bidirectional roller type		
33.	¢ distance of flat rollers	mm	1000 mm
34.	Applicable specifications		EIL std. 6-51-42
35.	Loss Capitalization		Not Applicable
a.	Rate for copper loss Rs./kW		
b.	Rate for iron loss Rs./kW		
36.	Accessories requirement		Yes
	Two temp. sensing		Yes
	devices in each limb		
	Marshalling box(IP-55)		Yes
	Temp. sensing relay		Yes
	Channels, towing lugs :		Yes
	Rollers		Yes
	Neutral bushing		Yes
	outside terminal box		
	with connector assembly		
	Indicating platinum		Yes
	resistance type		
	thermometer with contacts		

Rev. No.	Date	Purpose	Prepared By	Reviewed By	Approved By
A	13-MAR-2019	ISSUED WITH TENDER	BANSAL VARUN	SAHU MANJIT KUMAR	SAHU MANJIT KUMAR

Project PMC Services for Execution of Rajasthan Refinery Project (RRP) **Client** HRRL - REGD. OFFICE

Unit Delayed Coker Unit **Location** **Job No.** B224 **Unit No.** 114

	Busduct flange on LV	Not Required
	Lugs and cable glands	Required
37.	Tests requirements	
	Impulse test	Test Certificate Reqd.
	Heat run test	Test Certificate Reqd.
38.	Partial discharge test	
	(cast resin)	Test Certificate Reqd.
	Short circuit test	Test Certificate Reqd.
	Acoustic sound	Test Certificate Reqd.

MANUFACTURER'S DATA

1.	Make		
2.	Rated power at ambient temperature of		
	25 °C		
	30 °C		
	35 °C		
	40 °C		
	45 °C		
	50 °C		
3.	Insulation type		
B.	**Performance**		
1.	No load loss at		
	100% voltage	kW	
	110% voltage	kW	
2.	Full load copper loss at 75 °C	kW	
3.	No load current at		
	100% voltage	A	
	100% voltage	A	
4.	Efficiency at full load at 75 °C		
	at 0.8 p.f	%	
	at 1.0 p.f	%	
5.	Eff. at half load at 75 °C		
	at 0.8 p.f	%	
	at 1.0 p.f	%	
6.	Load at which max eff. occurs	MVA	
7.	Regulation at 75 0 C		
	at 0.8 p.f	%	
	at 1.0 p.f	%	
8.	Maximum efficiency	%	
C.	**Mechanical data**		
1.	Core & winding weight	kgs.	
2.	Total weight	kgs.	
3.	Wheel gauge		
4.	Overall dimensions		
	Length	mm	
	Breadth	mm	
	Height	mm	

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Project PMC Services for Execution of Rajasthan Refinery Project (RRP) **Client** HRRL - REGD. OFFICE

Unit Delayed Coker Unit **Location** **Job No.** B224 **Unit No.** 114

Eil Notes

Rev. No.	Date	Purpose	Prepared By	Reviewed By	Approved By
A	13-MAR-2019	ISSUED WITH TENDER	BANSAL VARUN	SAHU MANJIT KUMAR	SAHU MANJIT KUMAR

उच्च वोल्टेज वैरीएवल फ्रीक्वेन्सी ड्राईव सिस्टम के लिए निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN FOR HV VARIABLE FREQUENCY DRIVE SYSTEM

2	30.01.2014	Revised and Reissued	MJ	RS	SCG	SC
1	29.06.2012	Revised and Reissued	AB	RJD	AKC	DM
0	08.12.2008	Issued for implementation	RB	SKD	SKP	VC

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	

Abbreviations

AS	:	Alloy Steel	MPT/MT	:	Magnetic Particle Testing
BASEEFA	:	British Approval Service for Electrical Equipment in Flammable Atmospheres	MRT	:	Mechanical Run Test
BIS	:	Bureau of Indian Standard	MTC	:	Material Test Certificate
CCE or CCOE	:	Chief Controller of Explosives	MOC	:	Material of Construction
CEIL	:	Certification Engineers International Limited	NPSH	:	Net Positive Suction Head
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NEMA	:	National Electrical Manufacturers Association
DFT	:	Dry Film Thickness	PD	:	Partial Discharge
DT	:	Destructive Testing	PO	:	Purchase Order
DPT	:	Dye Penetrate Testing	PESO	:	Petroleum Explosive Safety Organization
ERTL	:	Electronics Regional Test Laboratory	PQR	:	Procedure Qualification Record
FCRI	:	Fluid Control Research Institute	PR	:	Purchase Requisition
FM	:	Factory Mutual	PMI	:	Positive Material Identification
FLP	:	Flame Proof	PVC	:	Poly Vinyl Chloride
HT	:	Heat Treatment	QC	:	Quality Control
HIC	:	Hydrogen Induced Cracking	TC	:	Test Certificate
ITP	:	Inspection and Test Plan	TPI or TPIA	:	Third Party Inspection Agency
IP	:	Ingress Protection	UT	:	Ultrasonic Testing
IC	:	Inspection Certification	UL	:	Under writer Laboratories
IGC	:	Inter Granular Corrosion	VDR	:	Vendor Data Requirement
IEC	:	International Electro technical Commission	WPS	:	Welding Procedure Specification
JEC	:	Japanese Electro technical Committee	WPQ	:	Welders Performance Qualification
LPT	:	Liquid Penetrate Testing	XLPE	:	Cross Linked Poly Ethylene

Inspection Standards Committee

Convenor : Mr. S.C. Gupta

Members:

Mr. R.K. Singh
Mr.Neeraj Mathur
Mr. Mayank Jain
Mr. Rajeev Kumar
Mr. T Kamalakannan
Mr. Himangshu Pal
Mr. Deepak Gupta (Project)

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of HV Variable Frequency Drive System (VFD).

2.0 REFERENCE DOCUMENTS

PO/PR/ Standards referred there in/Job specifications/Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**	--	--	--	--	--	--
2.0	**Material Inspection**						
2.1	Incoming Material like fabricated panels, Power semiconductors, IGBT/SCRs, relays, meters, CT/PT, transducers transformer unit, rectifier unit, filter etc.	• Material Identification • Operational checks	100%	Material Test Certificates / Test Lab Certificates	H	H	R
3.0	**In process Inspection**						
3.1	VFD Assembly	Visual ,Dimensional, Bill of Materials	100%	Supplier's records	-	H	R
4.0	**Final Inspection**						

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.1	Final Inspection ** (Acceptance tests)	• Visual and Dimensional • Check calibration status of all testing equipment. • Bill of Material. • Simulation check of control signals • Check of Speed/rpm at different frequency at constant Torque/ Voltage/ Power Mode, as applicable • Memory function check of fault diagnostics • Insulation Test • Light Load and Functional test • Load characteristics • Load duty test • Check Auxiliary Devices • Check the properties of the control equipment • Check the Protective Devices • Check control and functional requirements • High voltage test • Leakage and pressure test for cooling system where provided • Automatic restart/re-acceleration. • Noise Level Measurement	100%	Supplier's Records	-	H	H
4.2	Final Inspection (Type Tests)	• Load current versus speed at different frequency at constant torque/ Voltage/Power Mode as applicable. • Efficiency • Temperature rise • Voltage division	One sample from each type/rating	Supplier's records	-	H	H

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
		• Line side current distortion content • Power factor • Dynamic performance test • Current limit and current loop test • Speed loop test capability to ride through voltage dips upto 20 % • Test capability to restart the system and resynchronize converter onto running motor after a voltage interruption. • Noise Level Measurement. • Harmonic measurement at output of VFD for Volatge and Current **Integral Test is to be carried out along with job motor, as per PR/ EIL Standard Specification.**					
4.3	Submission of certificates /documents	• Degree of protection certificate as per latest IS/IEC. • Type test certificates from recognized independent test house such as ERTL, CIMFR,BASEEFA,FM/UL, PTB, ATEX etc for rated current test, power loss determination, temperature rise, EM Immunity and EM Emission	Sample/Prototype	Statutory Approval Certificates / Type Test Certificates	-	H	R
5.0	**Painting**						
5.1	Painting and Packing	• Visual • Protection against damage during transportation.	100%	Packing list / Supplier's Records	-	H	-

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
6.0	**Documentation and IC**						
6.1	Documentation and IC	• Review of Internal Test Reports and MTCs. • IC issuance	100%	Supplier's Test Records / Inspection Certificate (IC)	-	H	H
6.2	Final Document submission	Compilation of Inspection reports ,drawings, etc as per VDR / PR	100%	Final data folder /Completeness certificate	-	H	H

** All the load tests/ Functional Checks are to be carried out either with the job motor or with Shop Motor

Legends: H- Hold (Do not proceed without approval, R-Review, RW-Random witness (As specified or 10 % - Samples must include min 1 No of each type), W- Witness (Give due notice, work may proceed after scheduled date).

NOTES :-

1. This document describes the generic test requirements. Any additional test or inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon).
2. Acceptance Norms for all the activities shall be as per PO/PR/ Standards referred there in/ Job specifications /Approved documents

अग्निरोधक नियंत्रण स्टेशनों के लिए निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN FOR FLAMEPROOF CONTROL STATIONS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2.	21.11.2013	Revised and Reissued	MJ	RS	SCG	SC
2	29.06.2012	Revised and Reissued	AB	HVJ	AKC	DM
1	28.09.2007	Revised and Re-issued	AKG	PPM	MVKK	VC
0	30.04.2002	Issued for implementation	RG	AKC	AKB	GRR

Abbreviations

AS	:	Alloy Steel	MPT/MT	:	Magnetic Particle Testing
BASEEFA	:	British Approval Service for Electrical Equipment in Flammable Atmospheres	MRT	:	Mechanical Run Test
BIS	:	Bureau of Indian Standard	MTC	:	Material Test Certificate
CCE or CCOE	:	Chief Controller of Explosives	MOC	:	Material of Construction
CEIL	:	Certification Engineers International Limited	NPSH	:	Net Positive Suction Head
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NEMA	:	National Electrical Manufacturers Association
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DT	:	Destructive Testing	PESO	:	Petroleum Explosive Safety Organization
DPT	:	Dye Penetrate Testing	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
FM	:	Factory Mutual	PVC	:	Poly Vinyl Chloride
FLP	:	Flame Proof	QC	:	Quality Control
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	TC	:	Test Certificate
ITP	:	Inspection and Test Plan	TPI or TPIA	:	Third Party Inspection Agency
IP	:	Ingress Protection	UT	:	Ultrasonic Testing
IC	:	Inspection Certification	UL	:	Under writer Laboratories
IGC	:	Inter Granular Corrosion	VDR	:	Vendor Data Requirement
IEC	:	International Electro technical Commission	WPS	:	Welding Procedure Specification
JEC	:	Japanese Electro technical Committee	WPQ	:	Welders Performance Qualification
			XLPE	:	Cross Linked Poly Ethylene

Inspection Standards Committee

Convenor : Mr. S.C. Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr.Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Flameproof Control Stations.

2.0 REFERENCE DOCUMENTS

PO/PR/ Standards referred there in/Job specifications/Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**	--	--	--	--	--	--
2.0	**Material Inspection**						
2.1	Incoming material like castings, glass, meters, Fasteners etc	Visual, Dimensional, Operational checks, Review of Manufacturer's Certificates etc. as applicable	100%	TC's/ Inspection & Test records / Lab Test Records	H	H	R
3.0	**In process Inspection**						
3.1	Flameproof enclosure without components	Routine Pressure test	100% by Supplier	Supplier's Test Records	-	H	R

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.0	**Final Inspection**						
4.1	Flameproof Control Station (Acceptance tests)	• Visual/Dimensional/BOM Checks • Plan Gap/Path/Clearances • Electrical/Functional Checks • High voltage test • IR test before and after High voltage	100% by Supplier 10% by EIL/TPIA	Test Records / Inspection Witness Record	-	H	H
4.2	Submission of Certificates & Documents	• Certificate of Statutory testing agency for suitability of area classification • Certificate of Statutory approval authority like CCoE/ PESO as applicable. • Valid BIS License as applicable • Degree of protection certificate as applicable	Samples	Certificates from test agencies	-	H	R
5.0	**Painting**						
5.1	Painting and Packing	• Visual • Suitable protection to prevent entry of foreign material. • Proper packing to prevent any damage during transportation and storage.	100%	Packing list / Supplier's Records	-	H	-
6.0	**Documentation and IC**						

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
6.1	Documentation and IC	• Review of Internal Test Reports & MTC • IC Issuance	100%	Supplier's Test Records / Inspection Certificate	-	H	H

Legends: H- Hold (Do not proceed without approval), Random 10% , R-Review, RW-Random witness, W- Witness (Give due notice, work may proceed after scheduled date).

NOTES :-

1. This document describes the generic test requirements. Any additional test or inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon).
2. Acceptance Norms for all the activities shall be as per PO/PR/ Standards referred there in/ Job specifications /Approved documents

CONTENTS

ABBREVIATIONS

cm	Centimeter
CS AS SS	Carbon Steel Alloy Steel Stainless Steel
IMCO	International Maritime Council
M^3	Meter Cube
MSDS	Material Safety Data Sheet
MT	Metric Ton
M	Meters
ODC	Over Dimensional Consignment
OWC	Over Weight Consignment
P.O.	Purchase Order

1. OBJECTIVE

The Objective of this procedure is to provide guidelines for Packing Marking of Project Materials to ensure safe Handling, Transportation Storage of Materials.

2. PACKING PROCEDURE

2.1 General

The following instructions are intended as minimum requirements, and adherence to these instructions in no way absolve or relieve the Supplier of any his responsibilities or obligations agreed in the P.O.

2.2 Purpose

Packing shall be sufficient to withstand without limitation, rough handling during loading unloading, inland ocean transportation, outdoor storage, exposure to extreme temperatures rain etc.

Packing shall be to ensure protection against both mechanical damage (shocks, rupture, breakage, loss) and corrosion (rain, salty atmosphere, etc.).

Packing includes pre-packing treatment and protection activities such as application of anti-corrosion, coating, pealing, desiccants, solvents, etc.

2.3 Climatic Conditions

Due to climatic extremes encountered during transit storage (i.e. extreme heat, high humidity and fine drifting sand) and the transport operation (i.e. road, sea or air), it is essential that protection and packing be of the highest standard.

2.4 Supplier s Responsibilities

- Supplier shall be responsible for compliance with these instructions and select the packing type according to the nature of the CARGO and transport facilities used.

- Supplier shall be responsible for the accuracy of the weights and dimensions declared and marking on packages. The packing list shall be in strict conformity with the packing contents.

- In case of damages due to improper packing, all resultant replacements required shall be promptly made by the Supplier. The liability of free replacements of damaged items (due to defective or insufficient packing and or protection, or for short supplied items) shall be entirely to Supplier and such supplies shall be made good at no cost to BUYER.

- BUYER reserves the right to reject the packing when the packing is not conforming to these instructions, and or when the packing does not ensure perfect protection of the CARGO.

2.5 Packing List

2.5.1 **Pro-forma Packing List:** before delivery of the cargo, Supplier shall send a Pro-forma Packing List to TPL. The Pro-forma Packing List shall clearly mention the following:

a) Total number of Packages,
b) Net and Gross Weight and dimensions of each package
c) Delivery Point and Date,
d) Information of Hazardous Cargo, if any,
e) Details of items packed in each package
f) Declaration of "Rust Prevention Agents & Removal Solutions" packed in each package
g) Any other details as informed by TPL time to time.

Supplier shall also submit the Containerized PL once the cargo will be stuffed into the containers.

2.5.2 A master list of all packages (mentioning package-wise weights dimensions) shall be prepared and kept in package no. one of the shipment. If the material is shipped unpacked, master packing list and individual packing list shall be placed in waterproof envelope and securely attached to the material with Galvanized, Stainless steel or Aluminium Wires.

2.5.3 Packing List must show, apart from other particulars, purchase order number and item tag, relevant material code for each item as per Purchase Order, actual contents in each case, net and gross weights, dimensions (LXBXH in cms), packing style and the total number of packages.

2.6 Packing Instructions

2.6.1 The material must be free from rust, dents, cracks and surface defects at the time of packing loading.

2.6.2 Adequate protection shall be provided to prevent seepage of water due to rains, rough sea weather etc.

2.6.3 Spares Tools Tackles shall be packed in separate package must be clearly marked as spares. It shall not be shipped unmarked alongwith the main equipment.

2.6.4 CS AS SS Pipes, Valves shall be protected with plastic end caps at both ends. All equipment nozzles openings will be suitably protected with wooden or plastic cover.

2.6.5 All electrical and instrumentation items shall be individually wrapped in polyethylene or polypropylene plastic sheets in additions to normal outside packing for protection against moisture. Openings in electric motors, generators and other electrical equipment shall be sealed with waterproof tape. Under no circumstances, fragile or delicate material should be packed with steel items. All fragile delicate items shall be packed in separate boxes.

2.6.6 For all pressure, temperature and flow instruments, which are not mounted on the equipment and shipped in loose, the measuring range must be mentioned in the packing list. and the range on the packing list should not exceed the scale range of respective indicator or meter. In case if the item is detailed in the packing list or in the purchase order as a separate item, but is mounted on a skid or panel, the exact location of mounting needs to be indicated for easier custom clearance and verification.

2.6.7 Supplier shall tag each item giving description of the item for easy identification by Customs Authorities as well as Site Store In-charge.

2.6.8 Cases and or Crates should be constructed using top quality plywood and shall be solid and robust. Under no circumstances shall fiberboard, cardboard or similar cartons be used as outside packing. Hay, straw or similar vegetable fibers subject to disease or fungus shall not be used in packing.

2.7 Hazardous Materials

2.7.1 Hazardous materials shall be packed separately and shall be labeled, marked, and certified in compliance with applicable government and international regulations.

2.7.2 Material Safety Data Sheet (MSDS) shall be sent to BUYER. MSDS shall also be attached to Packing List.

2.7.3 For explosives or other Hazardous items, which require prior approval by Statutory Authorities, Supplier shall submit all necessary documents for Buyer to obtain necessary approvals.

2.7.4 The Supplier shall produce hazardous cargo certificates, in accordance with the appropriate Government and International Transportation regulations for all shipments.

2.7.5 If there are any Radioactive material in the shipment, Supplier shall submit within 60 days from PO date, radioactive element name, its radioactive strength, brand name, chemical composition and physical properties, original materials, description of protective device and method in transportation, leakage rate in transportation, operation and maintenance manual, special packing and marking requirement (as per the guidelines set in IMCO regulations).

2.8 Types of Packing

Modes of packing

In accordance with the Type of Cargo, the following modes of packing shall be considered :

- Wooden cases
- Wooden crates
- Skid construction
- Non-returnable steel drums (export variety)
- Non-returnable cable drums
- Bundles
- 20 ft 40 ft non-returnable containers shipper s own containers

3. MARKING PROCEDURE AS PER INDIAN IMPORT POLICIES / DOMESTIC POLICIES

3.1 General

3.1.1 All markings shall be painted clearly and thickly with black oil-based ink on the front and rear panels of each package.

The minimum information should content as follows:

PROJECT NAME:	□ ..
CONSIGNEE :	□ ..
TPL P.O. No.	□ ..
ITEM TAG No.	□ ..
PACKAGE NO:	□ □ □ □ □ of □
GROSS WEIGHT:	□ □ □ □ □ □ □ □ □ KG
DIMENSIONS:	(L)□ □ cm x (W) □ □ cm x (H)□ □ cm
MADE IN:	□ ..
Supplier NAME:	□ ..
DESTINATION PORT:	XXXXXXXXXXXX PORT

3.1.2 The Shipping Mark should be printed in the largest possible block letters. If packing is Bare, Bundle, Skid, Pallet, Crate (Wooden or Steel), Dura-Board, the shipping mark should be printed on plywood or tin plate firmly attached on at least two easily visible places.

3.1.3 Packages□equipment of five tons or more must be marked with slinging points and also clearly show on all sides the center of gravity.

3.1.4 All marking on the package shall be in English Language.

3.1.5 Fragile items shall be clearly marked, Fragile Handle with Care and or This Side Up etc.

3.2 International Standard Symbols

All boxes and crates shall also be marked with the appropriate international standard symbols for handling. All boxes and crates are to be marked clearly on all four sides:
"Handle with care" □"right side up" □"keep dry" □"hazardous" □"restricted" □sling □ fragile, "flash point", etc.

4. STORAGE & HANDLING OF CARGO

Supplier shall submit precaution for storage and handling of cargo, which requires special attention in handling. Supplier shall stencil appropriate instructions for the handling, transport and storage of the equipment and material on the outside of the package.

5. PHYTOSANITARY / FUMIGATION CERTIFICATE

If Wood is used as packing material, Supplier shall obtain Phytosanitary Fumigation Certificate from appropriate Authority in the Export Country.

This Certificate is mandatory for imports into India.

6. ODC / OWC / Transport Drawings

For ODC, SUPPLIER is obliged to respect the relative regulations for such transportation and get necessary permits as per agreed price basis in due time prior to dispatch of the goods.

SUPPLIER should submit the proposed transportation drawing sketch clearly mentioning all dimensions (Length x width x Height) and weight to TPL, after getting detailed drawing approval. This will be an approval category document and the comments from TPL shall be incorporated by SUPPLIER with no cost and time implication to TPL.

FORM SP-11(iii)

PRICES FOR POST WARRANTEE COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT SERVICES FOR VFD

SR.NO.	DESCRIPTION	PRICE	
		FOREIGN CURRENCY COMPONENT (IN CURRENCY AS INDICATED IN FORM-SP-0)	INDIAN CURRENCY COMPONENT (IN INR)
1.	Comprehensive post warrantee Annual charges for maintenance of VFD after 2 years extended warrantee of all types comprising of deployment of minimum one Supervisor including supply of spare parts and deployment of extra personnel required for repair or replacement of the above systems for the following periods:		
	a) First year after expiry of extended warranty period		
	b) Second year after expiry of extended warranty period		
	c) Third year after expiry of extended warranty period		
	d) Fourth year after expiry of extended warranty period		
	e) Fifth year after expiry of extended warranty period		
	TOTAL PRICES (a b c d e)		

Note: 1. EPCC-04 Contractor to provide 2 years extended warrantee of all VFD after completion of Defect liability period. Comprehensive post warrantee Annual Maintenance Contract (CPWAMC) period shall start after completion of 2 years extended warrantee period,

JOB SPECIFICATION (ELECTRICAL)

EPCC-04 PACKAGE FOR DELAYED COKER UNIT (DCU) AND LPG TREATING UNIT

TENDER NO. B224-114-86-41-PM-T-7204

PROJECT : RAJASTHAN REFINERY PROJECT

UNIT : 114

OWNER : HPCL RAJASTHAN REFINERY LIMITED

PMC : ENGINEERS INDIA LIMITED

JOB NO. : B224

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by
B	17.05.2019	REVISED ISSUED WITH TA-1	VB	MKS	MKS
A	13.03.2019	ISSUED FOR TENDER	VB	RS	MKS

Proper sealing baffles or frame shall be installed to separate busduct sections inside and outside building in order to prevent interchange of air between the sections.

The minimum head clearance for personnel movement for cross cable trays in cable cellar shall be 1800mm for escape routes. The cable cellar clear height shall be decided accordingly.

The air-conditioning ducts in substation shall be so mounted that they do not fall above the switchboard and do not obstruct illumination.

Fire fighting system like emulsifying system for transformers, water sprinkler system for cable cellar, portable type CO_2 extinguishers, sand buckets, Fire paint etc shall be provided for substation, transformer bay etc. as per statutory regulations and as defined elsewhere.

Switchboards shall not be located on the building expansion joints. If unavoidable, dummy panel shall be provided on expansion joint.

Mono rail with chain pulley block shall be provided above 66kV GIS isolator breaker panels for installation and maintenance.

Any other civil work required for completion of work is included in contractor's scope of work.

4.6.17 RCC LINED TRENCHES/CABLE TRAYS

(i) Overhead electrical cable Trays shall be provided for cable cellar in substations, plant unit area and upto SRR.

(ii) Cables for different voltage grades shall be laid in independent cable trays. Separate cable trays shall be provided for control cables.

(iii) Wherever trenches trays within battery limit have interface with the trays and trenches outside battery limit, the details shall be finalized during detailed engineering.

(iv) It shall be contractor's responsibility to co-ordinate the cable trench tray routing from other contractor and other agencies involved. Trenches and trays shall be provided up to the battery limits as per the final approved layouts.

(v) Cable trenches in unit shall be sand filled.

(vi) Refer plot plan for exact location of substation, SRR and unit for further details and estimation of cabling.

(vii) All HV MV power cables in racks trays shall be laid in single layer only.

(viii) Single core cables shall be laid in Trefoil configuration.

(ix) 20 spare space shall be provided in cable trays trenches.

(x) Cable trays covers shall be provided for top most cable trays and vertical trays. Further wherever trays crosses hydrocarbon lines, bottom covers shall be provided.

(xi) Cable tags shall be made from Stainless steel and numbers shall be engraved. SS wires to be used for binding Cable Tags.

4.6.18 ECS SYSTEM

Refer ECS system job specifications. Doc No. B224-114-16-50-SP-7205 attached.

4.6.19 HV VFD

a. Motors and VFD shall be suitable for the driven equipment for the required conditions as specified elsewhere.
b. VFD shall be V F controlled type.
c. All HV switchboard feeders, input transformer (if applicable) and VFD shall be part of the single line up board.

d. Motors shall be started through VFD system consisting of suitably rated input transformer (if applicable), power electronic circuits to reduce the voltage frequency at the time of starting so that starting current is restricted to a value not more than 1to 1.5 times rated full load current. The VFD system shall be complete in all respects including all connections between the breakers other components, VFD panels and input transformer (if applicable). VFD shall have facility for make before break (during switching over to Bypass). VFD system sizing calculation including sizing of input transformer (if applicable) shall be furnished for owner's review.

e. VFD panel shall include line PT(as required) on outgoing side of VFD and any other hardware required for synchronization of output breaker and bypass (DOL) breaker (in order to generate synchronizing signal for bypass etc,) and all other control and protections required shall be in vendors scope (as required).

f. Input transformer (if applicable) for VFD shall be panel mounted dry type suitable for indoor installation and comply with EIL standard specification 6-51-0044, clause 5.5.2 of Specification for HV variable frequency drive system (Doc. No. 6-51-0050) Dry type transformer datasheet.

g. VFD though shall be installed in Air-Conditioned Non-air-conditioned area but it shall be suitable for continuous operation in non-air-conditioned area.

h. Suitable hardware (including all CTs, PTs, cables etc.) software as required for satisfactory operation of VFD system, online transfer of VFD mode to bypass (DOL) mode bumpless operation of the motor shall be provided.

5.0 COMPREHENSIVE POST WARRANTY ANNUAL MAINTENANCE CONTRACT (CPWAMC)

Comprehensive post warranty annual maintenance contract for 5 years duration shall be provided for VFD ~~Soft starter Substation Automation System (SAS) UPS DC System Thyristor control panel system~~ and to be executed after expiry of warranty.

In the event of any malfunction of the system hardware system software, experienced service engineer shall be made available at site within 48 hours on the receipt of such information from OWNER. Owner personnel will work on system day-to-day basis and wherever possible, owner shall inform the type of failure of hardware software to Bidder Contractor based on diagnostic available with the system. However Bidder Contractor shall be fully responsible to attend and rectify the root cause and the failure at the shortest possible time.

The contract shall include supply of maintenance spares, tools tackles as required, travel, boarding lodging of service engineer. The quote shall be made year wise up to 5 years. Contract shall include on-site stock and shall provide cost of each item after expiry of 5 years AMC with escalation formula.

The service under Post Warranty Maintenance Contract including supply of spare parts and services shall broadly cover the Periodic maintenance, Emergency service, Software support, etc. as per the following:

a) Periodic maintenance:

Four no. pre defined visits per annum for inspection of general healthiness of the VFD ~~Soft starter Substation Automation System (SAS) UPS DC System Fire alarm system PA System Thyristor control panel system ECS,~~ study and advice on daily maintenance, inspection of hardware and software shall be provided. If any problem malfunction is reported, the running of test programs, on-line servicing and resolution to reported problems shall be done. Checks shall be conducted on the following running system:

i. On-line sub-systems
ii. Power supply checks
iii. Bought out items peripherals

Pre-defined visits shall start immediately from the next month after commissioning. HRRL will have the right to reschedule the visits. Each Visit shall be of Min 2 days including to fro charges, lodging and boarding and shall conclude only after the deliverables are achieved as per the approved check list. Checking of computer printer hardware and software is also be covered in these visits, no other extra cost will be reimbursed for the same.

b) **Software/ Hardware maintenance:**

Maintain existing software hardware, providing antivirus software to improve and utilize existing application and improve performance of the system. Minor modification of the software shall also be covered under this scope. During the CPWAMC period if bidder feels that the system require software release up gradation necessarily then same shall be provided without any additional cost implication to HRRL.

c) **Emergency Service:**

Any failure shall be on system suppliers' account. The Engineer must report at site within 48 hrs of report of failure, with necessary spares. The system must be brought back within 48 hours after reporting at site. These visits shall not be counted as part of pre-defined visits.

NOTE:

"Contractor to note that while carrying out the Post Warranty Maintenance Contract activities, Owner's (HRRL) engineers may associate with system engineers. On-job training of these associated engineers shall be covered under this scope. All financial aspects of the Comprehensive Post Warranty Maintenance Contract must be listed clearly by the Contractor."

6.0 MISCELLANEOUS REQUIREMENTS

(i) Variable frequency drive panels equipments for motor equipments shall be provided as per licensor process package requirements.

(ii) VFD systems shall be sized taking care of input voltage variation (i.e. 10) and voltage drop within the VFD system.

(iii) All cable glands adopter blocking plug for hazardous area equipment shall comply with requirements of IS IEC 60079-0.

(iv) Contractor shall furnish complete relay coordination and relay settings for the complete package including coordination with other EPCC contractor owner, relay settings for the upstream feeders.

(v) Power system study shall be carried out in ETAP. Contractor shall furnish the native file of ETAP after carrying out the preliminary study and also along with the final report.

(vi) It is CONTRACTOR's responsibility to identify and supply the safety equipment such as hand gloves, apron, eye shields, danger boards, first aid box, UPS panels etc., portable fire extinguishers in substation building and other equipment for safety of all electrical equipment and personnel as per statutory regulations.

(vii) All outdoor electrical equipment's i.e. motors, LCS, switch sockets, LP PP, FCS, MCP, etc. shall be provided with FRP canopy.

(viii) Safe and hazardous area lighting fixtures shall be provided with external reflectors.

(ix) Wherever single core cables are to be terminated in switchboard, aluminium gland plates shall be provided.

(x) Tinned copper lugs having sector shaped circular barrel shall be used for making connections for cables having sector shaped circular geometry of conductor respectively.

(xi) Contractor shall include painting and marking of all buses, individual incomers, all outgoing feeders etc. with detail such as Tag no., feeder rating, sending end source reference etc. for all switchboards.

(xii) Paint shade for indoor electrical equipment shall be RAL 7032 and for outdoor electrical equipment shall be RAL 7031.

(xiii) HV busducts shall be air insulated type only. MV busducts shall be Sandwich type.

(xiv) For termination of aluminium cables to copper bus or copper cables to aluminium bus, bimetal lugs shall be used.

(xv) Sealing of cut-outs for switchboards on switchgear hall floor shall be properly done after placement of chequered plates.

(xvi) Proper stencilling showing reading date with letters of radium stickers to be done on each and every Earth Electrode.

(xvii) Use of power junction boxes for cable terminations to be avoided to the extent possible. Use of power junction box shall be under exception cases subject to Owner's approval.

7.0 INSPECTION AND TESTING AT MANUFACTURER'S WORKS

(i) All major electrical equipment and material shall be subject to inspection by owner PMC or authorized representative at manufacturers' works. Contractor/Vendor/ Sub-Vendor shall furnish all necessary information concerning the supply to owner PMC.

(ii) Contractor shall ensure that the electrical equipment procured have type test certificates. Type test certificates for HV and MV switchboards shall not be more than five years old. In those cases where type test certificates are more than five years old, contractor manufacturer shall carry out the type tests at CPRI or any authorized testing lab prior to dispatch of equipment with no commercial implication.

(iii) During fabrication, all the equipment shall be subject to inspection by owner PMC or by an agency authorized by the owner to assess the progress of work as well as to ascertain that only quality raw material is used.

(iv) Routine and acceptance tests as listed in relevant Indian standard and equipment specifications shall be conducted. Type test if listed in ITPs and in the relevant data sheet shall be conducted. Type test, if specified, shall be conducted only on one of equipment of each type and rating. These tests shall be carried out by the Contractor vendor sub-vendor and shall be witnessed by owner PMC or an agency authorized by owner PMC.

(v) Contractor shall ensure that the hazardous area equipments provided shall have the necessary test certificates and valid CCOE approval certificates.

8.0 FIELD TESTING & COMMISSIONING

(i) Contractor shall carry out the installation, field testing and commissioning of all items of electrical equipment including installation, assistance in field testing and commissioning of free issue items such as fire detection and alarm system equipment, plant communication system equipment, etc. Further appropriate test and commissioning reports and as-built documentation as necessary for all electrical equipment shall be provided.

(ii) Field testing and commissioning of HV switchboards, numerical relay and integrating equipment, VFD, UPS system, soft starter, battery chargers electronic equipment and large rated motors shall be done by OEM (Original Equipment supplier). For other

equipment, contractor shall ensure services of manufacturers' representatives for supervision of installation, testing and commissioning.

(iii) Contractor shall coordinate with manufacturers of other equipment wherever required and shall freely and readily supply all technical information for this purpose as and when called for.

(iv) All electrical equipment shall be said to be installed and mechanically complete after circuit testing, primary and secondary injection testing and loop simulation is complete. Due care and consideration shall be given to the installation of all equipment, materials and facilities.

(v) Obtaining clearance for energizing the complete electrical facilities covered under this tender and approval of installation drawings from central electrical inspector and any other concerned approving authority e.g. CEA, TAC, CCE, DGFASLI etc. is in contractor scope.

9.0 TWO YEARS SPARES

Bidder shall furnish the required spares for two years of normal operation and maintenance for all electrical equipment with itemized quantity and unit rate. However owner will decide ordering as per their requirement.

10.0 MAKES OF EQUIPMENT/COMPONENTS

(i) Refer elsewhere in the bid document for acceptable makes of major electrical equipment and electrical components.

(ii) Contractor vendor while ordering shall ensure the availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply. Contractor vendor shall give a notice of at least one year to the Owner and PMC before phasing out the products spares to enable the owner for placement of order for spares and services.

(iii) Contractor Vendor may procure material from any of owner PMC-approved vendors. However current validity and range of approval as per PMC enlistment letter, workload, stability and solvency need to be verified by the vendor contractor before placement of order.

(iv) Contractor Vendor can offer equipment components of makes other than specified in the tender during order execution. The alternate make of equipment components will be evaluated post order, based on the satisfactory track record and test certificates to be furnished by the Vendor Contractor. In case the alternate makes are not found acceptable, equipment components shall be strictly as per vendor list enclosed with the tender.

(v) For equipment components not listed in the Vendor list such as EHV GIS isolation breaker panel, EHV cable termination kits; Contractor shall submit the 1 year operation certificate, PTR (Past Track Record) and Valid Type test certificates for review by Owner PMC.

EHV GIS supplier shall submit 1 year operation certificate, PTR for offered models manufactured assembled at proposed works with details of sourcing sub-assemblies of various equipment components (if sourcing of any equipment component is from overseas principals). The type test reports shall be for the GIS manufactured assembled supplied from the proposed works with identical sourcing sub-assemblies as being offered.

शुष्क किस्म के लाईटिंग ट्रांसफॉर्मर के लिए निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN FOR DRY TYPE LIGHTING TRANSFORMER

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	21.11.2013	Revised and Re-issued	MJ	RS	SCG	SC
1	29.06.2012	Revised and Re-issued	RKP	RJD	AKC	DM
0	08.12.2008	Issued for implementation	RB	SKD	SKP	VC

Abbreviations

AS	:	Alloy Steel	MPT/MT	:	Magnetic Particle Testing
BASEEFA	:	British Approval Service for Electrical Equipment in Flammable Atmospheres	MRT	:	Mechanical Run Test
BIS	:	Bureau of Indian Standards	MTC	:	Material Test Certificate
CCE or CCOE	:	Chief Controller of Explosives	MOC	:	Material of Construction
CEIL	:	Certification Engineers International Limited	NPSH	:	Net Positive Suction Head
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NEMA	:	National Electrical Manufacturers Association
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DT	:	Destructive Testing	PESO	:	Petroleum Explosive Safety Organization
DPT	:	Dye Penetrate Testing	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
FM	:	Factory Mutual	PVC	:	Poly Vinyl Chloride
FLP	:	Flame Proof	QC	:	Quality Control
HIC	:	Hydrogen Induced Cracking	RT	:	Radiography Testing
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IC	:	Inspection Certification	UT	:	Ultrasonic Testing
IGC	:	Inter Granular Corrosion	UL	:	Under writer Laboratories
IEC	:	International Electro technical Commission	VDR	:	Vendor Data Requirement
JEC	:	Japanese Electro technical Committee	WPS	:	Welding Procedure Specification
LPT	:	Liquid Penetrate Testing	WPQ	:	Welders Performance Qualification
			XLPE	:	Cross Linked Poly Ethylene

Inspection Standards Committee

Convenor : Mr. S C Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr.Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing & inspection requirements of Dry Type Lighting Transformer.

2.0 REFERENCE DOCUMENTS

PO/PR & Standards referred there in /Job specifications / Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**	--	--	--	--	--	--
2.0	**Material Inspection**						
2.1	Incoming Raw Material like Copper Conductor, Lamination, Marshalling box, cables, fasteners and bolts, copper flexible, insulators, dials, Scanners and gauges etc.	• Dimensional and Operational checks • Physical, Chemical, Electrical properties (as applicable) • Calibration checks (as applicable)	100%	Material Test Certificates / Test records	H	H	-
3.0	**Inprocess Inspection**						
3.1	Transformer Assembly	Visual, Dimensions, Bill of materials.	100%	Test Records	-	H	-

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.0	**Final Inspection**						
4.1	Transformer (Routine Tests)	• Physical and dimensional check. • Measurement of winding resistance • Measurement of voltage ratio and check of voltage vector relationship • Measurement of impedance voltage, short-circuit impedance and load loss. • Measurement of no-load loss and current • Separate –source voltage withstand test (HV test) • Measurement of Insulation Resistance before and after HV test. • Induced over voltage withstand test	100%	Inspection test records	-	H	H
4.2	Transformer (Special Test)	• Temperature rise • Noise Level Test	One sample from each type/rating	Inspection test records	-	H	H
4.3	Transformer (Type Test)	• Short circuit test • Impulse Withstand Test. • Partial Discharge Measurement. • Degree of Protection of Enclosure.	One sample from each type/rating	Inspection test records	-	H	R
5.0	**Painting**						
5.1	Painting and Packing	• Visual, Packing list. • Proper packing to avoid any damage during transportation.	100%	Supplier's records	-	H	-
6.0	**Documentation and IC**						

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
6.1	Documentation and IC	• Review of Internal Test Reports. • IC issuance	100%	Supplier's Test Records / Inspection Certificate (IC)	-	H	H
6.2	Final Document submission	Compilation of Inspection reports ,drawings, etc as per VDR / PR	100%	Final data folder /Completeness certificate	-	H	H

Legends: H- Hold (Do not proceed without approval, R-Review, RW-Random witness (As specified or 10 % - Samples must include min 1 No of each type), W- Witness (Give due notice, work may proceed after scheduled date).

NOTES :-

1. This document describes the generic test requirements. Any additional test or inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon).
2. Acceptance Norms for all the activities shall be as per PO/PR/ Standards referred there in/ Job specifications /Approved documents