TECHNICAL SPECIFICATION FOR MILL CIRCUIT PUMP

1. Intent of specification

This specification is intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing and delivery to site, supervision of erection and commissioning of Mill Circuit Pump along with its accessories complete in all respects.

The pumps shall be designed for continuous operation capable of delivering the rated flow at rated head with margins as specified in the specification. The mill circuit slurry pump is used to feed the limestone slurry (mixture of limestone and water) to hydrocyclone in wet ball milling system. The pumps shall be suitable for indoor application. The pumps shall be belt driven by a motor with VFD.

In case of additional requirement of instrumentation, controls and other accessories/auxiliaries for safe, reliable and trouble-free operation of the pump, necessary reasons for recommendation shall be furnished and the same shall be included in scope of supply with the purchaser's approval.

2. Applicable codes and standards

The design, manufacture and performance testing of the pumps as specified herein shall comply with requirement of all applicable codes in particular the following.

1. IS-5120/1977: Special purpose pumps Centrifugal type
2. API 682: Shaft sealing system for centrifugal & rotary pump
3. API 670: Machinery protection system
4. ANSI B16.5, B16.47: Pipe flanges and flange fittings
5. ANSI B16.9: Butt weld fittings
6. ANSI B16.11: Forged steel fittings, socket welded and threaded
7. ASTM: For various materials & tests
8. ISO 9906 Rotodynamic pumps hydraulic performance acceptance
9. ISO 3555/1977 Acceptance tests for centrifugal, mixed flow and axial flow Pumps-Class 'B' tests
10. ISO 2548/1973 Acceptance tests for centrifugal, mixed flow and axial flow Pumps-Class 'C' tests.

3. Scope of supply

Supplier scope shall include Design, Supply and Supervision of Erecting & Commissioning of mill circuit pump connecting belt & pulley, motor, VFD, baseplate, along with instrumentation and associated sub systems. It shall cover complete mill circuit pump unit including sub-systems, start-up spares and special tools and tackles.

Design includes basic and detail engineering, preparation and submission of engineering drawings, calculations, datasheets, quality assurance documents, field quality plans and storage instructions, commissioning procedures, operation & maintenance manuals and performance guarantee test procedures.

Supply includes manufacturing, shop floor testing, stage inspections, final inspections, painting, packing & transportation to site, customer clearance/port clearance and any other statutory clearances/receipts.

Supervision of Erection & commissioning includes supervision of erection & commissioning, supervision of trial operation.

The schematic showing the limits of the scope of supply is provided below. Supplier to clearly specify all terminal points in the GA drawing & P&ID and submit it during proposal to confirm scope of supply.

4. PROJECT DETAILS:

Project	:	TSGENCO YADADRI
Ultimate Customer	:	TSGENCO
Location	:	YADADRI
Service	:	Continuous
Installation	:	In-door
Total number of milling systems	:	3
Total pumps in each milling system	:	2 (1 working + 1 standby)
Total number of pumps	:	6
Material code	:	BA9789141009

5. Design input data

5.1 Pump operating parameters:

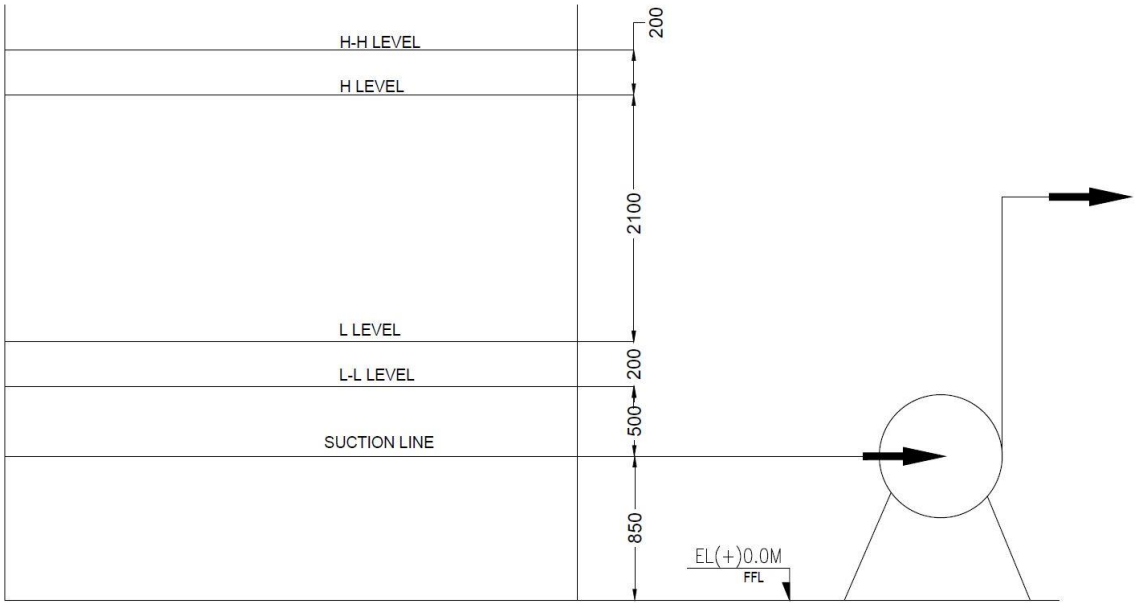
Discharge flow	280 m³/hr
Total Head developed	60 m of slurry
Medium to be handled	Limestone Slurry
Operating Temperature	65 deg C
Type of Recirculation pump	Horizontal, Centrifugal pump (non-clogging type)
Nozzle Orientation	End Suction- Top Discharge
Seal Type	Mechanical seal (Dry sealing arrangement)
Duty	Continuous operation
Location	Indoor
Drive type	VFD driven Motor with belt drive
Acceptable noise level	85 dBA (distance of 1.0 meter from the equipment at site and 1.5 m above operating floor)
NPSH(A)	5.9 m of Slurry

5.2 Slurry Analysis

Slurry to be handled	Limestone Slurry
Chloride Content max. (ppm)	27,000
Specific Gravity at pump suction (t/m3)	1.53
Vapour Pressure at Pump(kg/cm2)	0.216
Concentration of Solid	55% wt.
SiO2 Content	4 to 6 g/l
pH	6.0 to 8.0
Slurry Temperature (deg C)	65
Maximum solid particle size	3 mm
Normal solid particle size, d 50	74 microns

5.3 Mill Circuit Tank Level & NPSH

HH	**Bottom (FFL : 0.00 M) +**	**3850 mm**
H	**Bottom (FFL : 0.00 M) +**	**3650 mm**
L	**Bottom (FFL : 0.00 M) +**	**1550 mm**
LL	**Bottom (FFL : 0.00 M) +**	**1350 mm**
SL	**Bottom (FFL : 0.00 M) +**	**850 mm**



NPSH	SI Unit	Value
NPSH (A)	M of slurry	5.9

5.4 Cooling water analysis

Description	SI Unit	Value
Cooling water inlet temp	DegC	38
Cooling water outlet temp	DegC	< 48
Allowable increase in temp of cooling water	DegC	5 to 10

5.5 Operating methodology of pumps

5.5.1 The offered pumps shall be capable of operating satisfactorily in the entire operating range of the pump. Preferred operating range, 40% to 120% of BEP (Best efficiency point).

5.5.2 The individual pump duty conditions are indicated at clause 5.1. The operating media details are indicated at clause 5.2.

5.5.3 Pumps shall be operated as follows:

5.5.3.1.1 One (01) pump per milling system will be in continuous operation.

5.5.3.1.2 In order to optimize power consumption of wet ball milling system at part load operation, mill circuit pump shall be capable of variable speed operation and shall be driven by Variable frequency drive (VFD). The operating range of the pump shall be 40% to 120% of BEP point and pump shall be capable of operation.

Sl.No	Condition	Required total flow rate m3/hr	Required Pump Head m	Pump Efficiency (%)	Shaft Power consumption (KW)	Remarks
1	1 Pump in Continuous operation	280	60 m of slurry	> **60%**	##	

To be indicated by supplier & guaranteed by vendor

5.5.4 In the event of power failure, all the running pumps will be shutdown instantaneously, i.e. at the same time. Pumps discharge valve will close fully in 15 sec. During this time, pump shall be capable of handling the reverse flow.

6. Technical Requirements

6.1 All mill circuit pumps shall be identical and interchangeable.

6.2 The pumps shall be designed for continuous operation. The pump shall be single stage centrifugal type, capable of delivering the rated flow at rated head, duty parameters indicated at clause 5.1.

6.3 The pumps shall circulate the operating fluid from the mill circuit tank to the hydrocyclone cluster in the wet ball milling system.

6.4 The pumps shall be resistant to wear and be equipped with flushing devices to prevent sedimentation. They shall be designed and installed to allow easy replacements, repair and maintenance.

6.5 The pump bearing housings shall be equipped with oil level indicators and the collecting equipment for leakage shall made of corrosion resistant material.

6.6 All the equipment in scope of supply except wearing parts shall be designed and fabricated/manufactured for a service life of 30 years and at least 18000 hours of un-interrupted operation.

6.7 Pump shall be driven by the motor with belt.

6.8 All the parts coming in contact with the slurry shall be provided with replaceable rubber/elastomer liners suitable to the media handled. The supplier can also offer a Hi-chrome alloy lined pump if the Supplier has supplied a similar pump for a previous installation for similar service. The material used by the contractor shall be proven in previous installations.

6.9 The pump casing shall be designed to withstand a pressure of 1.5 times the maximum possible pump shut off pressure under maximum suction pressure condition.

6.10 Flushing water lines and drains are to be supplied for each pump handling the prevailing water to avoid corrosion even if the pump is out of operation for extended periods.

6.11 Pumps must be carefully selected to ensure that the net positive suction head available under all operating conditions will be adequate. The NPSH values are to be referred to the least favorable operating conditions such as lowest atmospheric pressure, lowest level of water on the suction side of the pump and highest temperature of the pumped fluid. An adequate safety margin of normally greater than 1m to the max NPSH required shall be provided. NPSH(R) at 120% of rated flow shall have margin over NPSH (A).

6.12 The Pump flow & head characteristics shall be such that within the operation range the head will continuously increase with decreasing flow. Shut off head being at least 20% higher than the duty point head.

6.13 Pumps shall have stable head-capacity characteristics curve from run-off to shut-off. Shut-off head should be minimum 125% of Best Efficiency Point (BEP).

6.14 Venting valve shall be fitted to all pumps at suitable points on the pump casing. Drainage facilities shall be provided on the pump casing or adjacent pipe work to facilitate the dismantling of pumps.

6.15 Pumps shall be designed such that they are not damaged during reverse rotation at up to 150% of design RPM, at full discharge head in the event where one pump trips while the other pumps are operational.

6.16 Selection of Duty point should preferably be at BEP (Best Efficiency Point). Duty point beyond 105% of BEP is not acceptable. It should be noted that head variation is due to level variation in tank. Pump has to run in the system without compromising the NPSH requirement at lowest water level in tank. Hence, when tanks are filled-up and is at normal water level, pump will operate at the right of BEP, pump's operating zone should be considered accordingly.

6.17 External flushing is required to remove the accumulated particles and all related information such as flow rate, pressure etc. should be mentioned in data sheet.

6.18 Pump should have provision for adjusting the axial clearance between casing and impeller for maintaining the performance at best efficiency when there is wear in between impeller and casing.

6.19 In case rubber or nonmetallic linings are used, these will be two pieces molded under pressure and adjusted to the screwed metallic clamping which have been welded to the casting.

6.20 The pump shall be provided with seals of proven type and shall be designed for minimization of seal water consumption. The shaft shall be supported on heavy duty ball/roller bearings.

6.21 A positive tolerance of up to 5% is allowed on rated flow and on rated head. No negative tolerance is allowed.

6.22 The Antifriction bearing of the pumps shall be designed for minimum useful life (L-10) of 25,000 hours of continuous operation (Under the design condition). The thrust bearing will be selected for twice the operating load.

6.23 Mechanical seal with dry sealing arrangement should be provided.

6.24 The sealing areas shall be designed in such a way so that solids do not precipitate in them and affect the cooling or affect the adjustment and mechanical functioning of the seals. Seals which do not need jet cleaning are preferred.

6.25 Flow induced vibration due to pressure pulsations shall be avoided by suitable design.

6.26 Each rotating equipment shall be first statically balanced and then dynamically balanced to G2.5 or better grade according to ISO 1940 (in the case of impellers this shall be done before and after mounting of the service rotor shaft).

6.27 The supplier shall perform lateral and torsional vibration analysis of whole unit assembly.

6.28 Allowable limits of foundation vibration shall be indicated in foundation drawing and general arrangement drawings.

6.29 The allowable vibration levels shall be indicated in the inspection procedure at shop and shall be demonstrated. The maximum vibration level shall be within permissible level as per the relevant internationally accepted standard.

6.30 Noise and Vibration level shall be specified in test procedure document and supplier shall be responsible for the values at the shop test as well as site.

7. Constructional features

7.1 Casing

7.1.1 The pump casing shall be split type for ease of maintenance and shall be designed such that the impeller and shaft can be withdrawn from the casing without disturbing the main pipework and valves carrying the pumped fluid and also without disturbing/removing the motor.

7.1.2 The casing and flanges shall be designed to withstand the 1.5 times the maximum shut-off pressure developed by the pump at the pump operating temperature.

7.1.3 Pressure casing shall be designed with a corrosion allowance (ASTM G46 & ASTM G48) to meet all the technical requirements, taking into account the Operating Parameters.

7.1.4 Lifting provision of pump as a whole and individual casing halves should be provided.

7.1.5 The casing material shall be Carbon steel / C.I with rubber lining or Silicon carbide or, Hi chrome or highly alloyed stainless steel or any equivalent. The material used by the contractor shall be proven in previous installations.

7.1.6 For replaceable rubber liner, hardness of rubber should be of Shore hardness- SA 65 (+/-) 5. Rubber should be of Type and Class as defined by ASTM D-2000 which is suitable for uninterrupted operation of 5 years (minimum). Guarantee to the affect shall be provided.

7.1.7 Pump casing shall be provided with a vent connection and piping with valves and fittings. Casing drain shall be provided with drain valves.

7.1.8 All the wear parts of the pump shall be guaranteed for a minimum wear life of not less than 25000 hrs.

7.1.9 Renewable wear rings shall be provided at points of minimum running clearances.

7.1.10 MOC of casing: ASTM A216 Grade WCC or equivalent/better.

7.2 Impeller

7.2.1 Impeller material shall be either Hi Chrome or a Silicon Carbide impeller or equivalent, guided by operating parameters taking into account the corrosion and erosion effect of the indicated slurry parameters.

7.2.2 Impeller as rotating assembly along with all elements should be dynamically balanced according to ISO 1940.

7.2.3 Impeller tip speed shall not exceed 28 m/sec. And Impeller shall have air bleed holes to eliminate any air accumulation around the shaft seal.

7.2.4 Impeller shall have a mandatory wear life of min. 25000 hours.

7.2.5 MOC of impeller: ASTM 532 Grade IIIA (Hi Chrome) with minimum hardness of 650 BHN or equivalent/better

7.3 Seals

7.3.1 Pump shall be supplied with mechanical seal (with dry seal arrangement). All mechanical seals, regardless of type or arrangement, shall be of the cartridge design.

7.3.2 Mechanical seals shall be of single type with either sliding gasket or bellows between the axially moving face and shaft sleeves or any other suitable type.

7.3.3 The sealing faces should be highly lapped surfaces of materials known for their low frictional coefficient and resistance to corrosion against the liquid being pumped.

7.3.4 The pump supplier shall coordinate with the seal maker in establishing the seal chamber of circulation for maintaining a stable film at the seal face.

7.3.5 The seal piping system shall form an integral part of the pump assembly.

7.3.6 For the seals under vacuum service, the seal design must ensure sealing against atmospheric pressure even when the pumps are not operating. Seals shall be fleshless type.

7.4 Shaft and Shaft Sleeve

7.4.1 Pump shaft shall be sized to transmit the maximum possible output from the motor.

7.4.2 The pump shaft to be so dimensioned that the maximum permissible torque of the shaft is higher than the maximum transmissible torque.

7.4.3 Pumps shall operate smoothly throughout the speed range up to their operating speeds. The first coupled critical speed must be at least 20% higher than the maximum operating speed. The determination of the shaft diameter and the distance between two consecutive bearings must include a sufficiently large safety margin to satisfy this condition.

7.4.4 Shafts shall be conservatively designed to transmit maximum power required and to assure rigidity. Shafts shall be machined and ground to close tolerances and shall be tapered to permit easy assembly & withdrawal of the seals and bearings.

7.4.5 Shaft shall run in high precision heavy duty roller bearings.

7.4.6 The shaft shall be finished to close tolerance at the rotor, coupling and bearing diameters.

7.4.7 Shaft shall be made of carbon steel. No exposed part of the shaft shall come in contact with the medium handled.

7.4.8 Shaft sleeve should be CD4M Cu ASTM A-743 or equivalent. Sleeve should have this as a guaranteed value/parameter to prevent wear and corrosion of mating surface. Manufacture to indicate the diameter in data sheet.

7.4.9 MOC of shaft: Stainless AISI-410 or equivalent/better

7.5 Base plate

7.5.1 A common base plate shall be provided for pump, gearbox & Motor and the same shall be rigidly constructed, adequately braced and provided with finish pads for mounting the equipment.

7.5.2 Common base plate for pump, gearbox and Motor shall be in the scope of the Supplier and the details of the Motor will be furnished to the Supplier to provide Motor mounting bolts.

7.5.3 Base plate must have provision for jacking the driver and driven equipment in both directions of base plate for alignment. Similarly, provision must be provided for alignment of shaft in vertical plane.

7.5.4 Pump manufacturer is to supply base plate along with Foundation bolt & Nut, shims/spacers, “Taper wedge” and the necessary fastener for Pump and Motor with Base plate. Even if Motor is excluded from their scope, necessary fastener for motor foot with base plate will remain in pump scope of supply in order to avoid any problem.

7.5.5 Base plate must be provided with a trough, material of which must be compatible to pumping liquid. Leaked liquid collected in trough, can be systematically routed to designated point.

7.5.6 Base plate must be stress-relieved for any residual welding stress and certificate to that effect is to be submitted as per inspection requirement.

7.6 Bearings

7.6.1 The bearings may be ball, roller or sleeve bearing. The bearings shall be designed to take the necessary radial load as well as the net axial thrust. Bearings shall be lubricated properly and sized for an operating life of 25,000 hours on the basis of maximum load. Bearing lubrication provided shall be such that visual inspection of lubricant level is possible.

7.6.2 The bearings shall be of automatic oil lubricated type. Bearing Temperature transmitter shall be provided with local monitoring of the bearing metal temperature. In case, external cooling water is required, flow, pressure, etc. shall be specified.

7.6.3 Bearing housings shall be designed such that they can be replaced without removing the pump or motor from its mounting. Supplier shall inform the bearing withdrawal

length for suitable selection of coupling. Bearing housings shall be effectively protected against the ingress of water, pumped fluid and dust by suitable nonferrous deflectors.

7.6.4 Bearing temperature transmitter shall be provided with local monitoring of the bearing metal temperature of pump. Bearing temperature Transmitter shall provide signals to FGD DCS for continuous monitoring.

7.6.5 Lubricating oil will be the responsibility of pump manufacturer. Hence, manufacturer has to make arrangement of first fill of oil at installation, and at commissioning stage. Quantity of oil and its grade is to be indicated in Drawing and Operation Manual.

7.7 Accessories

7.7.1 Expansion Joints

7.7.1.1 Expansion Rubber Joints shall be provided at suction and discharge of each pump.

7.7.2 Pressure Gauges

7.7.2.1 Pressure Gauges shall be provided at suction & discharge of each pump. Pressure gauges of class 1.6 or better must be used. Pressure instrument for measurement of steady pressure at varying conditions shall operate in a band centered on 60% of its maximum range. Pressure gauges shall have a dial size of 160 mm.

7.7.3 Provision for Vibration Monitoring:

7.7.3.1 Suitable provision/pads for mounting vibration sensors, Key phase sensors shall be provided on pump. For each bearing there shall be provisions for Two (02) No's of Vibration sensors (X and Y Axis) for vibration measurement. Provisions shall be provided in line with API 670 Vth Edition Standard These provisions shall be covered suitably. Details to be provided along with the offer.

7.7.4 Temperature elements:

7.7.4.1 Temperature elements wherever provided shall be duplex 4 wire type RTDs.

7.7.4.2 All RTD connections along with signal cables shall be terminated to Junction Box. Junction Box shall be provided along with Gear Box & Pump with 20% spare terminals.

7.7.4.3 Triple redundancy shall be supplied for parameters concerning the safe operation of the pump, Double redundancy shall be supplied for interlock and alarm signals.

7.8 Pump Control

7.8.1 Each pump shall be provided with required instrumentation and electrical accessory devices mounted and connected in a control cabinet.

7.8.2 Provisions shall be made for the interface between the local cabinet and the DCS such that the operation of the pumps can be controlled from the control console in the FGD Control room.

7.8.2.1 <u>Alarm Signal</u>

7.8.2.1.1 Bearing temperature high

7.8.2.1.2 Bearing temperature sensor for alarm when "Bearing Temperature high" shall be supplied by Supplier.

7.8.2.1.3 Cooling water flow switch for initiating alarm when "Cooling water flow low" shall be supplied by Supplier (if applicable).

7.9 Drive Unit:

7.9.1 The pumps shall be driven by electric motor with VFD through belt drives.

7.9.2 Drive unit power rating shall be the maximum of the following requirements.

a) 15% margin over the pump shaft input power at the rated duty point.
b) 5% margin over the maximum pump shaft input power required within the 'Range of Operation'.

7.9.3 The motor shall be as per IEC: 60034-1 with efficiency class IE3.Degree of protection: IP 55. Insulation class: F (temperature rise limited to class B) applicable for VFD application.

7.9.4 For detailed specification of VFD, refer clause 17.5/annexure-5.

8. General Requirements:

8.1 Metric unit shall be used in the drawings and any displays on the equipment. Unit of pressure shall be in dual scales of kPa and kg/cm2 (G). For instance the pressure gauges should have dual unit's indication.

8.2 The equipment shall be designed to withstand the corrosive and moist environment in which these are proposed to operate.

8.3 Noise level produced by the rotating equipment shall not exceed 85 dB measured at a distance of 1.0 meters from the source in any direction and 1.5m above operating floor. Predicted sound pressure levels for the pump drive assemblies shall be submitted as part of the proposal data.

8.4 The overall vibration level shall be as per ISO 10816.

8.5 Suitable drain connections shall be provided.

8.6 The equipment shall be suitable for stable continuous operation.

8.7 Service life: Entire pump except wearing parts shall be designed and fabricated for a minimum service life of 30 years of operation.

8.8 Corrosion allowance: Corrosion allowance for entire equipment shall be in accordance with latest applicable international standard ASTM G46 & ASTM G48.

8.9 Unless otherwise specified, flanges shall be in accordance with ANSI B16.5 Class 150 or ANSI B16.47 Class 150. Counter flanges along with suitable gaskets and fasteners shall be provided for all terminal points.

8.10 Name plate: All equipment shall be provided with nameplates indicating the item number and service name. Name plates shall be of 304 Stainless steel plate and placed at a readily visible location. Nameplate of main equipment shall have enough information, which will be confirmed during engineering phase. Stainless steel nameplates for all instruments and valves shall be provided.

8.11 Rotation arrows shall be cast in or attached with stainless steel plate on each item of rotation equipment at a readily visible location.

8.12 Unless otherwise specified, all equipment items where the weight exceeds 15 kg shall be provided with suitable lifting lugs, ears or ring bolts or tapped holes for lifting rings. Equipment shall be fabricated as skid mount design as much as practical to minimize erection at the site.

8.13 The position of earth lugs shall be shown on the GA and/or outline drawing.

8.14 Foundation bolts shall be provided with double nuts.

8.15 Supplier shall provide allowable vibration level on foundation in foundation drawings and general arrangement drawings.

8.16 If the driver/driven equipment train is in the resonance condition or any vibration problems occur, the Supplier shall solve the problems in a timely manner.

8.17 The Supplier shall have responsibility for vibration control of the equipment train at the site and the unit's satisfactory performance.

8.18 Supplier to quote for the Initial Spare parts, Mandatory Spares for equipment.

8.19 Supplier shall provide the mating flanges with the necessary gaskets.

8.20 All the surfaces of the carbon steel should have rust preventive coating durable for at least 18 months for storage from day of shipping.

8.21 Supplier to indicate the weights of components for handling.

8.22 The list of all Bought out items with makes to be mentioned along with offer to be submitted.

8.23 Cost towards the participation in discussions/meetings, providing technical assistance during technical discussions/meetings with customer for approval of drawing/documents etc. TA/DA, boarding and lodging to attend these meetings shall be borne by the Supplier and shall be inclusive in supply portion.

8.24 Supplier shall consider MOC for all equipment/component as per best engineering practice, global standard and global references.

8.25 The modalities of inspection (Stage, Final, In-process) shall be finalized during detail engineering after submission of quality assurance plan (QAP). It shall be reviewed by BHEL/end customer.

8.26 Supplier has to submit the following documents along with inspection call and if any other documents required as per approved QAP.

8.26.1 Raw material inspection certificate
8.26.2 Internal test reports
8.26.3 Statutory certificates as required.

8.27 All inspection & testing shall be carried out based on the following documents:

8.27.1 Relevant Standards
8.27.2 Specifications
8.27.3 Approved drawings
8.27.4 Data Sheets
8.27.5 Calibration certificate for all the measuring instruments
8.27.6 Supplier should also coordinate in getting the Material Dispatch clearance certificate and all types of Inspection Certificates from the end customer along with BHEL

8.28 Providing shim plates for erection of the pump at site shall be in the scope of Supplier.

8.29 During detail engineering, Supplier to strictly adhere to BHEL drawing formats, document numbering, quality plan formats.

8.30 Complete detail engineering drawings, calculations, selection of components etc. shall be reviewed & subject to approval of BHEL/end customer during detail engineering.

8.31 Supplier shall furnish necessary inputs & drawings of all equipment in editable Auto CAD/ MS-Word /Excel format.

8.32 During detail engineering, successful Supplier shall ensure flow of drawings/documents as per schedule. Any comments from BHEL/end customer should be addressed timely by the Supplier.

8.33 Supplier shall submit the signed and stamped copy of all the pages which constitutes this technical enquiry specification signed by authorized signatory and clearly mentioning each clause under following two categories to avoid any ambiguity in scope understanding & the scope division along with technical offer.

8.33.1"Accepted without deviation and considered in scope of work" **[or]**

8.33.2"Not considered in scope of work"

9. Packing

9.1 Packing shall be as per relevant product packing specification.

9.2 Cardboard containers shall be enclosed in a solid wooden container

9.3 Equipment and process materials shall be packed and semi-knocked down, to the extent possible, to facilitate handling and storage and to protect bearings and other machine surfaces from oxidation. Each container, box, crate or bundle shall be reinforced with steel strapping in such a manner that breaking of one strap will not cause complete failure of packaging. The packing shall be of best standard to withstand rough handling and to provide suitable protection from tropical weather while in transit and while awaiting erection at the site.

9.4 Equipment and materials in wooden cases or crates shall be properly cushioned to withstand the abuse of handling, transportation and storage. Packing shall include preservatives suitable to tropical conditions. All machine surfaces and bearings shall be coated with oxidation preventive compounds. All parts subject to damage when in contact with water shall be coated with suitable grease and wrapped in heavy asphalt or tar impregnated paper.

9.5 Crates and packing material used for shipping will become the property of end customer.

9.6 Packing (tare) shall be part of the equipment cost and shall not be subject to return. The packing should ensure integrity and cohesiveness of each delivery batch of equipment during transportation. In case of equipment assemblies and unit's delivery in the packing of glass, plastics or paper the specification of packing with the material and weight characteristics are to be indicated.

9.7 Each package should have the following inscriptions and signs stenciled with an indelible ink legibly and clearly:

9.7.1 Destination
9.7.2 Package Number
9.7.3 Gross and Net Weight
9.7.4 Dimensions
9.7.5 Lifting places
9.7.6 Handling marks and the following delivery marking

9.8 Each package or shipping units shall be clearly marked or stenciled on at least two sides as follows.
NAME OF THE PROJECT: ……..
AREA: ……, INDIA
EPC CONTRACTOR: BHARAT HEAVY ELECTRICALS LIMITED, INDIA

9.9 Each case shall contain a packing list in waterproof material or protected by shellac or varnish to prevent obliteration in transit, showing the detailed contents of the package. When any technical documents are supplied together with the shipment of materials no single package shall contain more than one set of such documents.

Shipping papers shall clearly indicate in which packages the technical documents are contained.

9.10 The case number shall be written in the form of a fraction, the numerator of which is the serial number of the case and the denominator the total number of case in which a complete unit of equipment is packed.

9.11 Wherever necessary besides usual inscriptions the cases shall bear special indication such as "Top", "Do not turn over", "Care" , "Keep Dry" etc. as well as indication of the center of gravity (with red vertical lines) and places for attaching slings (with chain marks)

9.12 Marking for Safe handling: To ensure safe handling, packing case shall be marked to show the following:

9.12.1 Upright position

9.12.2 Sling position and center of Gravity position

9.12.3 Storage category

9.12.4 Fragile components (to be marked properly with a clear warning for safe handling)

10. Supervision of Erection and Commissioning

10.1 The erection of Mill Circuit Pumps will be done as per Erection & commissioning Manual and check List. However, the Supplier shall make one visit for the supervision of erection, pre-commissioning & post- commissioning check-up, start-up, testing and trial runs of all the items covered under the scope of supply.

10.2 Supplier shall include 10 working days in the visit. Per day cost of visit shall be furnished separately. This shall be considered for evaluation of offer. Separate service order shall be issued for each visit.

10.3 TA/DA, boarding and lodging shall be borne by the Supplier.

11. Exclusions

The following shall be exclusions in the scope:

11.1 Civil foundations.

11.2 Vibration monitoring system including sensors.

12. Inspection and Testing

12.1 Minimum Testing requirements to be considered are as below:

12.1.1 Hydrostatic test is to be conducted at 150 % of shut-off pressure and pressure shall be maintained for a period of not less than one hour. While arriving at the above values maximum suction pressure shall be taken into account.

12.1.2 Impeller and rotor shall be first statically balanced and then dynamically balanced according to ISO 1940 (in the case of impellers this shall be done before and after mounting of the service rotor shaft).

12.1.3 List of Non-Destructive test over and above the material test are as follows:

12.1.3.1 Casing: Material test, Magnetic particle (MPI), DP and Hydro test as applicable

12.1.3.2 Impeller- DPT and MPI as applicable
12.1.3.3 Shaft- Ultrasonic (UT), DPT and MPI
12.1.3.4 Sleeve- DP and Hardness test/ Manufacturer's recommendation
12.1.3.5 Mechanical Seal- Manufacturer's recommendation.
12.1.3.6 Base Plate- Stress relieving of weld if applicable.
12.1.3.7 Replaceable Rubber liner- Shore Hardness, Class and Type certificate

12.1.4 Once mounting is finished, performance test will be conducted on each pump to determine the characteristic curves. The mechanical running & performance testing shall be performed & witnessed.

12.1.5 NPSH Test, Vibration test and Noise level test shall be done at vendor works.

12.1.6 For surfaces with rubber lining Welding shall be visually inspected to verify the absence of rough area and unacceptable transition between surfaces which prevent the adequate adherence of rubber. The acceptance criteria shall be as per latest standard.

12.1.7 For surfaces with rubber lining, degree of cleaning shall be visually checked before the application of the coating. There must be no area with oxidation, dirt or partially or generalized corrosion defects.

12.1.8 Test certificates shall be issued for each lot of raw material used in the coating, corresponding to specific weight and traction resistance.

12.1.9 For surfaces with rubber lining, adherence test shall be conducted on production samples. Adherence test shall be conducted on the actual surface through hammering. In order to verify the absence of air packets (or) surface without adherence.

12.1.10 For surfaces with rubber lining, Coating thickness shall be checked at 100%.A High voltage porosity test will be conducted on 100 % of the coated surface.

13. Painting

13.1 Surface Preparation: Power Cleaning Tool to St3 (SSPC-SP3)

13.2 Primer Coat

13.2.1 One coat of inorganic Zinc silicate
13.2.2 DFT= 50micron per coat
13.2.3 No of coats = 1.
13.2.4 Primer coat thickness: 50 micron.

13.3 Intermediate Coat:

13.3.1 One coat of Micaceous iron oxide (MIO) epoxy based paint.
13.3.2 DFT= 100 microns per coat

13.4 Finish Coat

13.4.1 Two coats of polyamide cured color pigment epoxy based paint.
13.4.2 DFT= 35 micron per coat
13.4.3 No of coats = 2.
13.4.4 Coat thickness 70 micron.
13.4.5 Total DFT : 220 micron.

13.5 Color Code for external surface shall be Grey White RAL 9002.

13.6 Rust preventive paint after inspection & before dispatch from shop is in Supplier's scope

13.7 Corrosion protection, coating and galvanizing, painting shall be taken care by the Supplier. Supplier shall submit the painting scheme during detail Engg and shall be subject to approval of end customer/BHEL.

14. Spares, Tools & Tackles

14.1 Start-up & Commissioning Spares

Start-up & Commissioning Spares shall be part of the main supply of the Mill Circuit pumps. Start-up & commissioning spares are those spares which may be required during the start- up and commissioning of the equipment/system. Supplier shall provide an adequate stock of such start up and commissioning spares for the equipment erection and commissioning. The spares must be available at site before the equipment is energized. These start-up & commissioning spare part list shall not be included in "Initial Spare Parts List".

14.2 Mandatory Spares:

Supplier to quote for below mentioned mandatory spares with break up price.

Sl.No	DESCRIPTION	QTY	UNIT	MATERIAL CODE
1	Casing Liner	2	EA	BA9789141017
2	Seals (Mechanical + other applicable seals)	2	EA	BA9789141025

Supplier shall quote for the “Mandatory Spares Part List”, and it will be considered for L1 evaluation. Mandatory spare parts items shall not be mixed with the supply of the main equipment parts. Spares shall be sent in pre-decided lots in containers/secure boxes, distinctly marked in red color with boldly written “S” mark on each face of the containers. The packing shall be sufficient for a minimum of 10 years storage in a dry weatherproof building.

All spares shall be strictly inter-changeable with the pump parts. All the mandatory spares shall have same specification and quality plan.

14.3 Special Tools & Tackles

Any special tools & tackles required for disassembly, assembly or maintaining the pumps, shall be included in the quotation and furnished as part of the initial supply of the machine. List of special tools & tackles shall be decided by Supplier as per his proven practice. They shall be packaged in separate boxes with lugs and marked as “Special Tools”. Moreover levers and eyebolts for the removal of parts to be serviced shall be included in the supply of each individual equipment.

15. Performance Guarantee

All performance tests for mill circuit pumps shall be carried out in accordance with any latest international codes/standards.

15.1 Supplier shall furnish Performance guarantee for the design, manufacture, material, safe and trouble-free operation of the Recirculation pump and its accessories.

15.2 Capacity and its associated head of the pump to be guaranteed.

15.3 All the wear parts of the pump shall be guaranteed for a minimum wear life of not less than 25000 hrs.

15.4 Scheduled Maintenance (Minor Overhauls): Recommended intervals between maintenance outages shall be >25000 hours operation.

15.5 Scheduled Maintenance (Major Overhauls): Recommended intervals between maintenance outages shall be >75000 hours operation.

15.6 Noise level-≤85 dB (A) at 1m horizontal distance from equipment/enclosures and 1.5m above operating floor is to be guaranteed.

15.7 Vibration levels measured on the non-rotating parts shall not exceed the zone limit "B" as defined in ISO 10816 at steady conditions and shall not exceed the zone limit "C" as defined in ISO 10816 at transient conditions.

15.8 Acceptance tests to be carried out as per the procedure defined by the Supplier which shall be submitted for BHEL/end customer approval.

15.9 In the event of unsuccessful performance test, Supplier shall take necessary remedial action at his cost and the performance test shall be repeated.

16. Documentation

16.1 Documents to be submitted along with the offer

The Supplier shall submit all documents, drawings, diagrams and all such information, which are necessary to fully understand the offer for techno – commercial evaluation. The following information shall be furnished along with duly filled-in Technical Data sheets at Annexure I and guarantee schedule furnished at Annexure-II.

16.1.1 Sectional Assembly, P&ID diagram
16.1.2 Performance curve
16.1.3 Terminal point details.
16.1.4 General Arrangement with civil loads and pocket details.
16.1.5 Rotor GD2 (kg-m2)
16.1.6 Torque Vs Speed curve
16.1.7 Calculation of Motor rating, Bearing capacity
16.1.8 Bill of material along with ASTM or its equivalent materials.
16.1.9 Overall space and headroom requirement during Erection, maintenance of pump.
16.1.10 Erection, Operation & Maintenance manual with lubrication schedule
16.1.11 Procedure for shop / site performance tests
16.1.12 Time schedule for delivery.
16.1.13 Deviation list
16.1.14 Spares list.
16.1.15 Hoist / Crane requirement.
16.1.16 Reference list of similar projects executed.

16.1.17 List of proposed makes and vendors
16.1.18 Equipment maintenance schedules

16.2 Documents to be submitted after award of contract

The Successful Supplier shall submit necessary data, documents and drawings for review, approval with requirements specified here under. However as minimum the following shall be submitted.

16.2.1 Duly filled technical datasheet.
16.2.2 General arrangement drawings indicating dimension and civil loading details.
16.2.3 Motor Data.
16.2.4 Recommended repair procedure etc.
16.2.5 Operation and maintenance manuals.
16.2.6 Assembly & Dis-assembly sequence shall be submitted as a separate document prior to the submission of the Operation and Maintenance Manual.
16.2.7 Erection schedule and component list.

16.2.8 The following performance curves of the pump shall be submitted:
16.2.8.1 Flow v/s Head
16.2.8.2 Flow v/s NPSH
16.2.8.3 Flow v/s Efficiency
16.2.8.4 Flow v/s power consumption
16.2.8.5 Torque vs. speed curve for Motor selection
16.2.9 The system-resistance point at different loads shall be indicated in the above performance curves.

Drawings that are reviewed will be returned to Supplier with a transmittal letter with any comments and / or questions marked on the drawings or noted in the letter. All comments and questions must be resolved before a resubmission of drawings / documents. BHEL reserves the right to return drawings unprocessed to Supplier if there exists any evidence that Supplier has not acknowledged all comments and questions.

<u>Note to supplier regarding mandatory spares:</u>

1. Supplier shall clearly indicate with a P&ID, drawings, various instruments used in the scope of supply and the highlight the mandatory spares diagrammatically to avoid any ambiguity. Supplier shall contact the purchaser in case of ambiguity, prior to submitting the offer. Revision/ Alteration after bid submissions shall not be considered.
2. Impeller assembly shall include, impeller, impeller nut & impeller keys.
3. Complete casing shall be one to one replacement of the existing casing.
4. Casing liners shall be a complete replacement of liners in the supplied pump, if applicable.
5. Set of seals shall include Mechanical seal, oil seals, wear rings at impeller location, oil thrower & oil guards in the entire scope of supply.
6. Bearings shall include journal bearings, thrust bearings in the entire scope of supply.

7. Connecting coupling set shall include couplings between pump & gearbox, gearbox & motor.
8. Set of Transmitters along with accessories shall include all the transmitters and its accessories where ever used in the entire scope of supply.
9. Temperature elements with Thermowell shall include all temperature elements where ever used in the entire scope of supply.
10. Local gauges along with accessories shall include all local gauges where ever used in the entire scope of supply.

17. ANNEXURES

17.1 Annexure-1, Technical Data Sheet

S.No	Description			Data
1	**GENERAL**			
	a. Client		:	Indicated in variant table.
	b. Project		:	--do--
	c. End Customer		:	--do--
	d. Location		:	--do--
	e. Service		:	--do--
	f. Installation		:	--do--
	g. No of pumps for each unit		:	--do--
	h. No of stand-by pumps per unit		:	--do--
	i. Total number of pumps		:	--do--
2	**MANUFACTURER DETAILS**			
	a. Model		:	*
	b. Type		:	Centrifugal (non- Clogging)
	c. Type of Driver		:	Motor with Gearbox/Belt
3	**OPERATING CONDITION**			
	a. Medium to be handled		:	Indicated in variant table.
	b. Maximum solid particle size		:	--do--
	c. Normal solid particle size, d 50		:	--do--
	d. Concentration of chloride		:	--do--
	e. Viscosity of slurry		:	--do--
	f. Concentration of slurry		:	--do--
	g. Specific gravity of slurry		:	--do--
	h. pH of slurry		:	--do--
4	**PERFORMANCE DATA**			
	a. Capacity	m^3/hr	:	*
	b. Head	M	:	*
	c. Pump efficiency	%	:	*
	d. BKW Normal / Maximum	KW	:	*
	e. Motor rating	KW	:	*
	f. Motor Speed	rpm	:	*
	g. Gear box Loss	%	:	*
	h. Differential pressure (inclusive of losses)	Kg/cm2	:	*
	i. Speed Maximum/ Normal/Minimum	rpm	:	*
	j. Noise level	dB(A)	:	*
	k. Performance curve		:	*

5	**CONSTRUCTION DATA**			
	a. Manufacturer		:	
	b. Model No.		:	*
	c. Suction Rating / Size		:	*
	d. Discharge Rating / Size		:	*
	e. Type of rotor		:	*
	f. Size of rotor Dia	mm	:	*
	g. Journal bearing: Type / Size:		:	*
	h. Thrust bearing: Type / Size:		:	*
	i. Bearing cooling required		:	Yes / No - Supplier to confirm
	j. Cooling water required		:	Supplier to confirm the quantity
	k. Type of drive		:	With Gearbox
	l. Shaft seal		:	Mechanical
	m. Size / Code		:	*
	n. Type of coupling		:	*
	o. Service factor		:	*
	p. GD^2 at drive shaft end		:	*
	q. Rotation viewed from coupling end		:	Clock wise / Counter clock wise
	r. Coupling type		:	Yes / No - Supplier to confirm
	s. Coupling make		:	*
	t. Base plate common to pump, Gearbox, bearing housing, coupling & Motor		:	Yes / No - Supplier to confirm
	u. Total weight	kg	:	*
	v. Maximum Erection weight	kg	:	*
6	**MATERIALS**			
	a. Casing		:	*
	b. Impeller		:	*
	c. Shaft		:	*
	d. Shaft Seal		:	*
	e. Base frame		:	*

7	**INSPECTION AND TESTING**		
	a. Material Test certificates required for : Casing, Impeller, shaft, shaft sleeve	:	[R] [O]
	b. DPT & MPI Test for impeller as applicable	:	[R] [O]
	c. Ultrasonic & Liquid penetrant test for shaft	:	[R] [O]
	d. Dimensional & visual inspection	:	[R] [W]
	e. Mechanical running test for 4 hrs.	:	[R] [W]
	f. Vibration test at rated speed	:	[R] [W]
	g. Performance test	:	[R] [W]
	h. Balancing test of Rotor Assembly	:	[R] [O]
	i. Noise level test	:	[R] [W]
	j. NPSH Test		[R] [W]
	k. Hydrostatic Test	:	[R] [W]
	[R]: Required, [W]: Witnessed by BHEL/ end customer, [O]: Observed		

*: Supplier to provide

SIGNATURE OF SUPPLIER ----------

NAME ----------

DESIGNATION ----------

17.2 Annexure-2, Schedule of guarantees

Sl.No	Description			Data
1.	Rated capacity of pump	m^3/hr	:	
2.	Total head at design capacity	m	:	
3.	Guaranteed shaft power consumption at rated capacity & head	kW	:	
4.	Noise level at a distance of 1.0 meter from the equipment at site and 1.5 m above operating floor	dB(A)	:	
5.	Maximum vibration (peak to peak amplitude at site)	microns	:	
6.	Equipment Availability (%)		:	
7.	Pump Efficiency (%)		:	
8.	Life of Pump wear parts including, Casing liners, bearing etc	Hours	:	≥25000 hours operation
9.	Scheduled Maintenance (Minor Overhauls): Recommended intervals between maintenance outages	hours	:	>25000 hours operation.
10.	Scheduled Maintenance (Major Overhauls): Recommended intervals between maintenance outages shall be	hours	:	>75000 hours operation.

SIGNATURE OF SUPPLIER ----------

NAME ----------

DESIGNATION ----------

17.3 Annexure-3, List of Deviations

S.No	Clause No	Page No	Description of Deviation

SIGNATURE OF SUPPLIER ----------

NAME ----------

DESIGNATION ----------

17.4 Annexure-4

17.4.1 Documents to be submitted along with offer

S.No.	Description	No of copies With proposal
1.	Duly signed Specification	1
2.	Price Sheet	1
3.	Anchor Plan & Civil foundation Loading details	1
4.	Data Sheet	1
5.	Performance curve, Motor T-S curve	1
6.	Pro-forma Packing List	1
7.	Approximate weight of each skid	1
8.	Reference plant details	1
9.	Required Electric power & other Utility List	1
10.	Deviation List	1
11.	General Assembly Drawing	1
12.	Pump and Motor Sizing Calculation	1
13.	Cross-sectional Drawing	1
14.	Sub-Vendor List	1
15.	Scope of Supply	1
16.	Spare List (Mandatory, Recommended)	1
17.	Start-up & Commissioning Spares	1
18.	List of Special Tools	1
19.	Delivery Schedule	1
20.	Test Arrangement & Test procedure	1
21.	Hoist/Crane requirement	1
22.	P & I Diagram	1
23.	Catalogue	1

SIGNATURE OF SUPPLIER ----------

NAME ----------

DESIGNATION ----------

17.4.2 **Documents to be submitted after award of contract**

S.No.	Description	No of copies After award of contract	Delivery Time
1.	Utility Consumption	1	2 weeks after contract
2.	Foundation Data including Anchor plan	1	2 weeks after contract
3.	Performance curve	2	2 weeks after contract
4.	General arrangement drawing	1	1 month after contract
5.	Cross section detail drawing	1	1 month after contract
6.	Data Sheet	1	2 weeks after contract
7.	Lubricating oil list	1	2 months after contract
8.	Special tools list	1	2 months after contract
9.	Installation and assembly procedure	1	4 months after contract
10.	Inspection and Test Procedure	1	1 month after contract
11.	Inspection & Test record	1	In 2 weeks after test
12.	Inspection Certificate	1	In 2 weeks after test
13.	Sub vendors List	1	2 weeks after contract
14.	Quality plan	1	2 weeks after contract
15.	Pro-forma Packing List	1	2 months prior to
16.	Approximate weight of pump	1	2 months after contract
17.	Delivery Schedule	1	2 weeks after contract
18.	Pump and Motor Sizing Calculation	1	2 weeks after contract
19.	Material Test Certificates	2	In 2 weeks after test
20.	Pre Commissioning Check List	2	4 months after contract
21.	Scope of Supply	2	2 weeks after contract
22.	Quality Plan	4	1 month after contract
23.	Operation and Maintenance Manual	Hardcopies and soft copies as mentioned	4 months after contract
24.	Spare List (Mandatory, Recommended)	1	1 month after contract
25.	Start-up & Commissioning Spares	2	1 month after contract
26.	List of Special Tools	1	1 month after contract
27.	Test Arrangement & Test procedure	2	1 month after contract

S.No.	Description	No of copies After award of contract	Delivery Time
28.	T-S curve	2	2 weeks after contract
29.	P & I Diagram	2	2 weeks after contract
30.	Catalogue	2	2 weeks after contract

SIGNATURE OF SUPPLIER ----------

NAME ----------

DESIGNATION ----------

17.5 ANNEXURE -5

SPECIFICATION OF VARIABLE FREQUENCY DRIVE (VFD)

1. General Requirement :

The VFD shall be selected for the motor (refer clause 7.9) which drives the mill circuit pump with variable speed.

2. Application :

The variable speed drive is used to drive the motor of a mill circuit pump in wet ball milling system in an electrical energy-generating power station. The motor drives the pump by means of V belt. A power plant distributed control system provides a signal to the VFD to regulate motor speed. The signal will be 4 to 20 mA DC. The motor and drive will be installed in a power plant application requiring reliable and continuous operation 24 hours per day and 365 days per year with minimal downtime maintenance.

3. Environmental Conditions :

The drive is to operate within an environment with temperatures ranging from 0°C to 50°C. The motor is to operate within an environment with temperatures ranging from 0°C to 50°C. The equipment and motor will be located in dusty environment which will result in the material settling on the equipment. The motor will be installed less than 500 meters from the VFD.

4. Scope of Supply :

The Supplier will provide the following items:

4.1 Variable frequency drive to meet specified electrical, control and construction requirements.

4.2 Variable frequency drive with enclosure cabinet with wired local control panel and necessary switchgears. Cabinet shall be of Rittal/ ABB or Siemens make. The cabinet shall have thermostatically controlled air conditioner. The dimension of cabinet shall not exceed 2000 x 1200 x700. All the operation & display shall be possible from front door of the panel without opening the door. It should be min. IP54.

4.3 VFD shall be provided with air cooled arrangement.

4.4 Certified drawings.

4.5 The Supplier shall indicate if output line reactors are required to prevent impedance mismatches and potential damage to the motor from voltage spikes. If output line reactors are required, the Supplier must quote them as an option

4.6 It is the supplier's responsibility to ensure the supplied VFD is satisfying all functional requirements as per clause 9.Vendor to include any or all accessories/equipment for the same even if not mentioned in this specification.

5. Power and speed requirements :

Vendor shall select the speed range of motor with VFD as per pump functional requirement.

6. Noise Requirements :

The Supplier shall furnish the drive motor to a maximum predicted sound pressure level of 85 dBA, measured 3 ft (1 m) horizontally from the surface of the motor. Allowable sound pressure level applies to one motor with negligible sound contributed by other equipment.

7. Low Voltage Starting:

The motor and drive must be capable of starting without damage to the motor with a supply voltage range of 90 – 110 % of motor nameplate voltage. The motor must also be capable of starting with 80% motor nameplate voltage.

8. Surface Preparation and Paint :

Equipment shall be prepared and painted per manufacturer's standard for a minimum of 10 year power station operating life in a tropical environment. Equipment must arrive at the site with a finished coat.

9. Variable Frequency Drive Requirements :

9.1 The system offered shall be energy efficient, provide very high reliability, high power factor, low harmonic distortion, low vibration and noise. It shall be easy to install with minimum time and expense and no special tools shall be required for routine maintenance.

9.2 The system shall be suitable for the load characteristics and the operational duty of driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torques, resulting from short-circuit. Any damage resulting from such a short-circuit or internal fault shall be limited to the component concerned.

9.3 The system shall be speed, torque or power controlled as dictated by the driven equipment.

9.4 The system shall be suitable for continuous speed control of the motors in single drive system as per data sheet and soft start feature shall be provided to reduce the disturbances in the electrical system.

9.5 The drive will vary the frequency of the supplied AC power to control motor speed according to a signal from the plant distributed control system (DCS). A 4 to 20 mA DC/0-10V DC signal from the DCS will represent 0 to 100% motor speed .VFD to have facility for user to configure range of speed for 4-20mA /0-10 V input signal.

9.6 The drive motor shall be speed regulated to a speed corresponding to purchaser's 4-20mA or 0-10 V reference signal. Upon complete loss of the DCS speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to the loss of signal.

9.7 All components of the drive system shall be mounted in an IP-54 enclosure fully accessible from the front.

9.8 In case of failure of VFD, for any reason, VFD shall have an in-built facility to immediately isolate VFD output and switch-On motor in DOL condition, via a bypass breaker.

9.9 Power semi-conductors shall be IGBT (Isolated Gate Bipolar Transistor) type. Fast switching SCRs are not acceptable.

9.10 The drive shall also include the

9.9.1 Electric Thermal overload protection.

9.9.2 Potential free contacts for local indication in control room for following functions : Supply Healthy, Run, Trip, Stop

9.9.3 4-20 mA signal follower.

9.9.4 Local Control panel, mounted on VFD panel, for user operation, with functions as per clause 12.

9.9.5 Connection for control keypad to be through the cabinet door.

9.9.6 Current limit adjustment 50% to 150% of drive rating

9.9.7 Independent acceleration and deceleration ramps adjustable from 0.1 of a second to 1800 seconds.

9.9.8 Slip compensation to improve speed regulation.

9.11 Vendor to select operation / type / quadrant of operation of VFD to be suitable for load / application characteristics.

9.12 The modulating control scheme shall closely approximate actual sine wave current throughout the speed range of the drive.

9.13 The regulator shall be fully digital with microprocessor control of frequency, voltage and current.

9.14 Speed resolution shall be within +/- 1 RPM.

9.15 All drive adjustments and custom programming, configuration etc. shall be capable of being stored in a non-volatile memory.

9.16 The drive shall be designed to protect itself against instantaneous current levels above 200% of its rating. The drive shall continue to operate through instantaneous current spikes below 200%.

9.17 Isolation transformers shall not be used to eliminate possible line converter notching of the input filter. The drive shall not be sensitive to line notching from other drives.

9.18 The drive shall be capable of automatic restart upon power failure or momentary source voltage dips, and restarting into a rotating motor at any speed without tripping.

9.19 The drive shall actively monitor its output current and frequency and shut down the drive if the motor is in a stall condition. A stall condition is defined as operating in current limit at or below 10 Hz for 10 seconds. This definition of stall shall be field adjustable to match the application.

9.20 Power capacitor voltage levels shall be discharged below 50 volts within one minute of de-energization or less per NEMA and NFPA standards.

9.21 The input displacement power factor of the drive shall be a minimum of 0.95 at all speeds and loads above 10% load.

9.22 Drive efficiency shall be evaluated and the Supplier shall provide drive efficiency curves for 0% to 100% speed at 25, 50, 75, and 100% rated load. Minimum acceptable efficiency shall be 97% at full load.

9.23 The drive shall be capable of operating with the output open circuited.

9.24 The Total Harmonic Distortion for Voltage and Current Harmonics shall be in line with latest revision of IEEE 519 standard at the supply side of the drive system based on the short circuit capacity of the bus.

10. Drive Protection :

Drive protection functions shall operate independent of the microprocessor control logic and shall include as a minimum:

10.1 Over current protection
10.2 Short circuit protection.
10.3 DC bus under voltage protection.
10.4 DC bus over voltage protection.
10.5 Over temperature protection.
10.6 Ground fault protection.
10.7 Electronic thermal overload monitor.
10.8 Settings for trip / alarm settings shall be user configurable either through software interface / local control panel.

11. Drive Diagnostics :

The drive shall include first fault indication in the protection functions and ability to store 20 successive fault indications in order of occurrence. As a minimum, the following fault indications shall be displayed on the local operator control panel:

11.1 Over current
11.2 Short circuit
11.3 Under voltage or phase loss
11.4 Over voltage
11.5 Over temperature
11.6 Motor Thermal overload

12. Drive Controls :

12.1 The drive shall be supplied with a local control panel which shall include the following operating functions
- **12.1.1** Drive Start and Stop
- **12.1.2** Fault reset
- **12.1.3** Provision to increase or decrease the local speed reference with accuracy to 1 RPM.
- **12.1.4** Local/remote selection.

12.2 The local control panel shall include a digital display to monitor the following functions:
- **12.2.1** Local frequency reference
- **12.2.2** Motor load calibrated in amps
- **12.2.3** Output frequency
- **12.2.4** Output voltage
- **12.2.5** Remote frequency references
- **12.2.6** Fault diagnostic messages
- **12.2.7** Trouble shooting test points
- **12.2.8** Motor speed

12.3 The local control panel shall be the operator interface for making all drive adjustments. Internal adjustments are not permitted.

12.4 The drive shall also include provisions for the following hard wired inputs and outputs for remote operator controls:

12.4.1 Digital inputs, 24 VDC contacts from plant controls including: 1 Drive start 1 Drive stop 1 Remote control selector 1 Run at present speed.

12.4.2 Digital output relay contacts 5 Amps 125 VDC / 250 VAC rating, 1 Drive off, 1 Drive running, 1 Drive fault.

12.4.3 Analog input for reference signal, 4 to 20 mA.

12.4.4 Analog output signal, 4 to 20 mA and/or 0 to 10 VDC to transmit output frequency and speed.

12.5 The drive is to be factory programmed and wired for:

12.5.1 having the speed ramped as a function of a 4 to 20 mA signal input

12.5.2 any trouble with the drive is to give a dry fault contact

12.5.3 the drive is to get its start and stop signal as an input contact from the DCS.

12.5.4 the drive is to output a signal indicating the motor speed.

12.5.5 the drive is to be programmed for an acceleration ramp of 60 Hz/180 seconds.

12.5.6 the drive is to be programmed for a deceleration ramp of 60 Hz/180 seconds.

12.5.7 the drive is to be programmed so that during a start cycle it will catch and stop a reversed spinning load before it starts it in the correct direction.

12.5.8 the drive is to be programmed so that if there is a loss of load it will trip and send out a fault signal.

12.5.9 the drive is to be programmed so that if the power (current) exceeds the motor name plate rating for more than 3 seconds, it will trip and send out a fault signal. This shall be configured from LCP.

13. Quality Assurance :

13.1 All work is to be done in accordance to the Manufacturing Quality Plan and so documented.

13.2 All material, components and subassemblies shall be inspected and/or tested for conformance to these specifications and Supplier's engineering and quality assurance specifications.

13.3 The Supplier shall on request make available for review copies of Supplier Quality Assurance Policy, documentation, and records pertinent to equipment purchased.

13.4 The drive is to conform to NEMA, IEEE, UL and IEC standards.

14. Testing :

14.1. Type Test & Routine Tests like, No load tests, Insulation test, Functional test, Rated current test & Visual inspection, etc.

14.2. No load tests includes: Motor shaft voltage & Vibration severity measured at bearing housing, etc.

14.3. Insulation test (vendor to specify with relevant standards).

14.4. During Inspection, any physical damage or non-working of the unit shall be replaced with new units**.**

15. Document submission :

1. Recommended Spare Parts List (motor and drive)
2. Drive Electrical Schematic Drawing
3. Drive Dimensional Drawing
4. Drive Parameter List -Settings
5. Drive Installation, Operation and Maintenance Manual (Electronic pdf format)
6. General Arrangement drawing, Test certificates, conformance certificates.

16. Preservation and Packaging :

16.1 The material is to be preserved for long term storage (two years minimum) without additional onsite preservation activities.

16.2 The motor and drive to be boxed in shrink-wrap covering.

RECORD OF REVISIONS

Rev.No.	Date	Revision Details	Revised by	Approved By