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TECHNICAL SPECIFICATION FOR ABSORBER SLURRY RECIRCULATION 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 Slurry Recirculation pump along with its accessories complete in all respects.

Each unit of 250/500/660/800MW, is associated with an FGD system. Each FGD system shall have recirculation pumps located inside Recirculation pump & Oxidation blower house. The pumps shall be suitable for outdoor application. The pumps shall be driven by a constant speed motor.

The offered pump model shall be proven and must meet the proven-ness criteria indicated at clause 3. The list of deviations/exceptions with respect to the specification shall be submitted as per annexure-4. Deviations not listed in the format shall not be considered. No deviations/exceptions shall be permitted without the approval of purchaser.

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.	ANSI HI 12.1~12.6:	Rotodynamic Centrifugal slurry pumps
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.	ASME sec VIII div. 1	
9.	ISO 9906	Rotodynamic pumps hydraulic performance acceptance

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3. Provenness Criteria

Supplier shall have previous experience of design, manufacturing, supplying, erecting and commissioning of the recirculation pump for Wet Limestone based FGD system for at least two (2) no's of PUMPS, each of capacity 9500 m3/hr or higher, in a pulverized coal fired power generating units such that the pump should have been in successful operation for a period of not less than two (2) years prior to January 2019. Documentary evidence as per annexure-3 at clause 23.3, shall be submitted along with the offer.

4. Scope of supply

Supplier scope shall include Design, Supply, Engineering Coordination and Supervision of Erecting & Commissioning of slurry recirculation pump, gear box, connecting couplings, baseplate, along with instrumentation and associated sub systems. It shall cover complete recirculation 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.

Engineering Coordination shall include full responsibility of design integration, inspection and test, installation/startup supervision, functioning and performance of equipment and auxiliaries. Analysis of complete driven equipment, gear, driver including lateral, torsional vibration and train performance. Coordination between driver and driven equipment, seals, oil system, couplings, guards, control and protection system, connecting piping, wiring if any. Submitting train drawings such as general arrangement, foundation, piping, instrumentation etc even if driver is provided by BHEL. The supplier shall incorporate driver details in all the relevant drawings.

Supervision of Erection & commissioning includes supervision of erection & commissioning, supervision of trial operation, training of customer's O&M Personnel and handing over to customer.

The schematic showing the battery 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.

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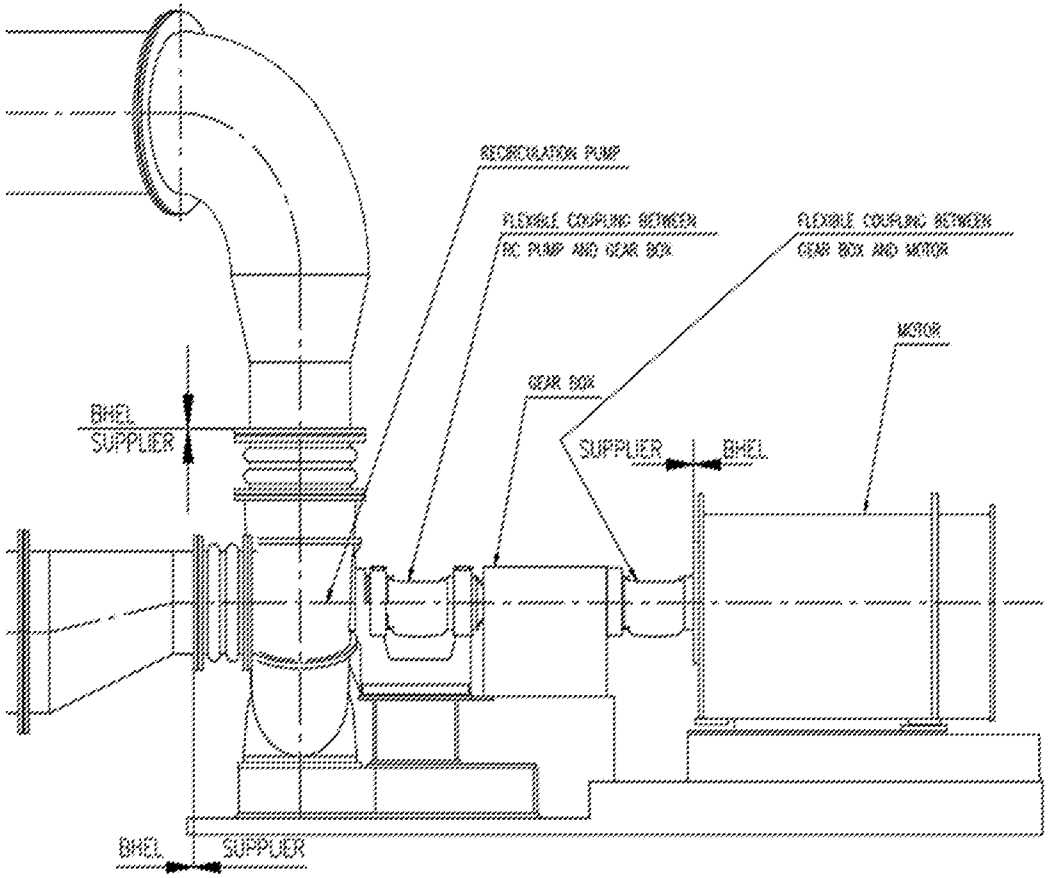

SCOPE:

1) RECIRCULATION PUMP WITH BASE PLATE
2) SUCTION SIDE AND DISCHARGE SIDE BELLOWS ALONG WITH COUNTER FLANGE AND FASTENERS
3) GEAR BOX
4) FLEXIBLE COUPLING BETWEEN RC PUMP & GEAR BOX AND GEAR BOX & MOTOR.
5) COMMON FOUNDATION FRAME FOR RC PUMP, GEAR BOX & MOTOR, FOUNDATION BOLTS
6) INSTRUMENTS RELATED TO RC PUMP AND GEAR BOX.
7) SPECIAL TOOLS AND TACKLES
8) COMMISSIONING SPARES
9) TEMPORARY STRAINER
10) COMPLETE LUBRICATION UNIT FOR PUMP & GEAR BOX(IF APPLICABLE) WITH PIPING & FITTINGS
11) PROVISIONS FOR VIBRATION ISOLATION SYSTEM & VIBRATION MONITORING SYSTEM ALONG WITH RECOMMENDATIONS

BHEL SUPPLIER BHEL: SCOPE OF BHEL
SUPPLIER: SCOPE OF SUPPLIER

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5. Variant table

Project	:	Yadadri TPP, 5x800MW	Bhadradri TPP, 4x270MW	Bhusawal TPS, 1x660MW
End Customer	:	TSGENCO	TSGENCO	MPGCL
Location	:	Nalgonda, Telangana, India	Manuguru, Telangana, India	Jalgaon, Maharashtra, India
Service	:	Continuous	Continuous	Continuous
Installation	:	In-door	In-door	In-door
Total number of units	:	5 units of 800MW	4 units of 270MW	1 unit of 660MW
Total pumps in each unit	:	5	3	4
Stand-by pumps per unit	:	1	1	1
Total number of working pumps	:	20	8	3
Total number of pumps	:	25	12	4
Variant	:	Var. 01	Var. 02	Var. 03
Material code	:	FP9760317001	FP9760317028	FP9760317036

6. Design input data

6.1 Pump operating parameters

Discharge flow	12,500 m³/hr	9,988 m³/hr	13,867 m³/hr
Total Head developed	18.40 m H	17.50 m H	18.00 m H
Medium to be handled	Gypsum slurry	Gypsum slurry	Gypsum slurry
Operating Temperature	~60 deg C	~60 deg C	~55 deg C
Type of Recirculation pump	Horizontal, Centrifugal pump (non-clogging type)		
Nozzle Orientation	End Suction- Top Discharge		
Seal Type	Mechanical seal with external flushing		
Duty	Continuous operation		
Location	Outdoor		
Drive type	Motor driven		
Acceptable noise level	85 dBA (at 1-meter from pump centreline)		
NPSH(A)	10.02 mlc	10.0 mlc	9.78 mlc
Variant	Var. 01	Var. 02	Var. 03

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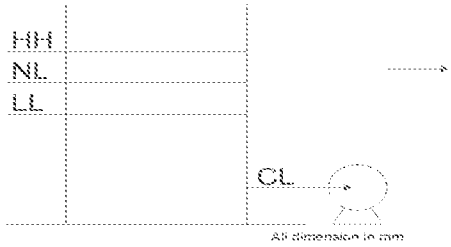
6.2 Slurry Analysis

Slurry to be handled	Gypsum Slurry		
Chloride Content	Less than 20,000 ppm		
Specific Gravity at pump suction (t/m3)	1.211 @ design point	1.215	1.204
	1.205 @guarantee Point.	1.207	1.203
Vapour Pressure at Pump	0.136 kg/cm2	0.136 kg/cm2	0.154 kg/cm2
Viscosity of slurry	0.01 Pa.S	0.01 Pa.S	0.01 Pa.S
Concentration of Solid	30% wt.		
SiO2 Content	4 to 6 g/l		
pH	Normal = 4.0 – 7.0		
	Design = 4.0 – 8.0		
Slurry Temperature	51.6 deg C (normal)	53.9 deg C (Normal)	54 deg C
	70 deg C (Max)	70 deg C (Max)	70 deg C
Maximum solid particle size	150 mesh(140 microns)		
Normal solid particle size, d 50	325 mesh(43 microns) & fine particles		
Variant	Var. 01	Var. 02	Var.03

6.3 Absorber Tank Level & NPSH

HH	**Bottom +**	**7,000**	**7,000**	**7,000**
NL	**Bottom +**	**6,000**	**6,000**	**6,000**
LL	**Bottom +**	**4,200**	**4,200**	**4,200**
CL	**Bottom +**	**1,200**	**1,200**	**1,200**
Variant		**Var. 01**	**Var. 02**	**Var. 03**



*NPSH (A) is based on Absorber LL level

NPSH Calculation	**SI Unit**	**Value**	**Value**	**Value**	
Discharge Pressure	kg/cm^{2}G	2.555	2.466	2.492	
Suction Pressure	kg/cm^{2}G	0.327	0.340	0.325	
Differential Pressure	kg/cm^{2}G	2.228	2.126	2.165	
Max. Suction Pressure	kg/cm^{2}G	0.666	0.680	0.662	
NPSH (A).	m	10..02	10.0	9.78	
Variant		Var. 01	Var. 02	Var. 03	

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6.4 Flushing water analysis

Variant no.1

Sr.No	Constituents	unit	Value
1	Calcium as CaCO3	ppm	121.9
2	Magnesium as CaCO3	ppm	74.1
3	Sodium as CaCO3	ppm	184.4
4	Potassium as CaCO3	ppm	1.1
5	Iron in Soln	ppm	Nil
6	Total Cations as CaCO3	ppm	381.5
7	Bicarbonate as CaCO3	ppm	134.8
8	Sulphate as CaCO3	ppm	80.9
9	Chloride as CaCO3	ppm	161.0
10	Nitrate as CaCO3	ppm	3.5
11	Total Anions as CaCO3	ppm	381.5
12	Reactive Slica as SiO2	ppm	14.1
13	Colloidal Silica as SiO2	ppm	Nil
14	Total Silica as SiO2	ppm	14.1
15	Nitrites	ppm	Nil
16	Total Hardness as CaCO3	ppm	196
17	Total Suspended Solids		15
18	PH Value at 25 deg C	-	7.0-8.2
19	Turbidity	NT|U	15
20	Fluoride	ppm	1.3

The following chemical dosage have been considered on the Raw water analysis for Pretreatment Plant and above clarified water analysis has been arrived

Chlorine dosing : 5 ppm
Lime dosing : 20 ppm
Alum dosing : 50 ppm
Poly electrolyte (PE) : 1 ppm

Variant no.2

Sr.No	Constituents as CaCO3	unit	Value
1	Calcium	ppm	136.5
2	Magnesium	ppm	52.0
3	Sodium + Potassium	ppm	76.6
4	Iron in Soln	ppm	Nil
5	Total Hardness	mg/l	188.50
6	Total Cations	mg/l	265.10
7	P-Alkalinity	mg/l	0.00
8	M-Alkalinity	mg/l	140.77
9	Bicarbonates	mg/l	140.77
10	Chlorides	ppm	76.23
11	SO4	ppm	46.50
12	NO3	ppm	1.60
13	EMA	mg/l	124.33
14	Total anions	mg/l	265.10

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15	Silica (reactive)	ppm	1.10
16	pH @25 deg C	-	7.5-8.0
17	Turbidity (maximum)	NTU	10
18	Suspended Solids	mg/l	10
19	TDS Calculated	mg/l	375.90
20	Conductivity @ 25 deg C	uS/cm	400
21	TDS (given)	mg/l	282.0
22	Temerature	Deg C	25

Variant no.3

Constituents	Units	Value	
Total Dissolved Solids	ppm	840	
Calcium as CaCO3	ppm	240	
Magnesium as CaCO3	ppm	120	
Sodium as CaCO3	ppm	252	
Potassium as CaCO3	ppm	33	
Iron as Fe	ppm	-	
Fluoride as F	ppm	-	
Bicarbonate as CaCO3	ppm	220	
Chlorides as CaCO3	ppm	140	
Sulphate as CaCO3	ppm	50	
Nitrate as NO_3	ppm	7	
Silica	ppm	48	
pH	-	7.0 – 8.5	
Turbidity	NTU	<10	
Variant		Var. 03	

6.5 Cooling water analysis

Description	SI Unit	Value	
Cooling water inlet temp	DegC	38	38
Cooling water outlet temp	DegC	< 48	<48
Allowable increase in temp of cooling water	DegC	10	5
Inlet pressure of cooling water	bar	3	3
Pressure drop of cooling water across pump	bar	0.5 (max.)	0.5 (max)
Variant		Var. 01	Var.02,03

Clarified water shall be used for CW system with suitable chemical treatment program using acid, scale and corrosion inhibitor dozing. As CW blow down water is tapped from CW system, the water quality of CW blow down shall accordingly be arrived by the bidder.

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6.6 Operating methodology of pumps

6.6.1 The offered pumps shall be capable of operating satisfactorily in the entire operating range of the pump. Preferred operating range, 60% to 120% of design.

6.6.2 All pumps of the unit are connected to the common header of the recirculation line.

6.6.3 The individual pump duty conditions are indicated at clause 6.1. The operating media details are indicated at clause 6.2.

6.6.4 Pumps shall be operated as follows:

6.6.4.1 Pumps shall be sequential started, one after the other.

Variant no.1

6.6.4.1.1 Four (04) pumps will be in continuous operation.

6.6.4.1.2 One pump per boiler will be standby

6.6.4.1.3 In order to optimize power consumption of FGD system at part load operation, slurry recirculation 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 duty point and pump shall be capable of operation.

S.No	Condition	Required total flow rate m3/hr	Required Pump Head m	Each Pump Capacity (m3/hr)	Pump Efficiency (%)	Shaft Power consumption (KW)	Remarks
1	4 Pumps in Continuous operation	50,000	18.40	12,500	**≥90%**	≤837	

Variant no.2

6.6.4.1.4 Two (02) pumps will be in continuous operation.

6.6.4.1.5 One pump per boiler will be standby

S.No	Condition	Required total flow rate m3/hr	Required Pump Head m	Each Pump Capacity (m3/hr)	Pump Efficiency (%)	Shaft Power consumption (KW)	Remarks
1	2 Pumps in Continuous operation	19,976	17.50	9,988	**≥90%**	≤675	

Variant no.3

6.6.4.1.6 Three (03) pumps will be in continuous operation.

6.6.4.1.7 One pump per boiler will be standby

S.No	Condition	Required total flow rate m3/hr	Required Pump Head m	Each Pump Capacity (m3/hr)	Pump Efficiency (%)	Shaft Power consumption (KW)	Remarks
1	3 Pumps in Continuous operation	41,601	18.0	13,867	**> 87%**	##	

- To be indicated by supplier.

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6.6.4.2 Pumps shall be sequentially stopped, one after the other.

6.6.4.3 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.

7. Technical Requirements

7.1 All recirculation pumps shall be identical and interchangeable.

7.2 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 6.1.

7.3 The pumps shall circulate the operating liquid from the absorber sump to the spray nozzles in the absorber.

7.4 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.

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

7.6 All the equipment in scope of supply except wearing parts shall be designed and fabricated/manufactured for a service life of 20 years and at least 18000 hours of un-interrupted operation.

7.7 Pump shall be driven by the motor with gearbox.

7.8 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, Carbon steel/CI lined with high alloyed stainless steel, a Silicon Carbide impeller and SiC lining for casing 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.

7.9 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.

7.10 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.

7.11 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

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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).

7.12 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.

7.13 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).

7.14 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.

7.15 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.

7.16 Selection of Duty point should preferably be at BEP (Best Efficiency Point). Selection 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.

7.17 A factor for "Froth" should be taken into account for sizing the pump. Supplier from their past experience, may specify the froth factor to be taken into account for FGD pump. Suction size of the pump should be adequate to take this extra capacity and the same should be reflected in master curve.

7.18 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.

7.19 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.

7.20 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.

7.21 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.

7.22 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.

7.23 Mechanical seal with automatic flushing, and an additional connection for manual flushing shall be provided.

7.24 The mechanical seals of cartridge type with self-lubrication sliding ring cartridges are preferable. The static part will be mounted on the seal plate with circumferential ring (O-ring) or another flexible sealing ring. Built in seal design will not be accepted.

7.25 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.

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

7.27 Material shall be selected considering urea and ammonia constituents in the atmosphere.

7.28 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).

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

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

7.31 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.

7.32 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.

8. Constructional features

8.1 Casing

8.1.1 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.

8.1.2 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.

8.1.3 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.

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

8.1.5 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.

8.1.6 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.

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

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

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

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8.2 Impeller

8.2.1 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.

8.2.2 Miller number for the material should be justified for that pumping medium as per ASTM G75-95 as well as the corrosion effect of pumping medium.

8.2.3 Base material for rubber-lined impeller should be capable of handling speed as specified in the respective clause without affecting adhesion of lining. Impeller as rotating assembly along with all elements should be dynamically balanced according to ISO 1940.

8.2.4 Impeller tip speed shall be as per vendor's experience. And Impeller shall have air bleed holes to eliminate any air accumulation around the shaft seal.

8.2.5 Full diameter of the impellers for the pump body shall not be quoted for. By installation of a new impeller a head increase of minimum 5% shall be possible.

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

8.3 Seals

8.3.1 Pump shall be supplied with mechanical seal. All mechanical seals, regardless of type or arrangement, shall be of the cartridge design.

8.3.2 The Mechanical Seals shall be so arranged that assembly/disassembly of seals can be carried out without any disruption to plant operation.

8.3.3 Design the mechanical seals chamber to have sufficient room to lubricate and cool the seal faces with its own slurry.

8.3.4 Seal shall have provision for periodical flushing to rinse the seal face off leaked slurry.

8.3.5 Flushing water requirement, either continuous or intermittent, quantity, pressure & duration to be indicated in data sheet.

8.3.6 Seal shall have zero visible leakage. However, quantity of leakage, if unavoidable, pump should have a provision of collecting and draining the same to nearby pit without corroding the pump frame.

8.3.7 Mechanical seals shall be fitted and installed in the pump before shipment and shall be clean. Seal shall have provision for locking during transit and when not in operation. Mechanical seals vent/drain holes shall be plugged during shipping

8.3.8 Intention of the specification is not to specify Type of Seal, Seal design, spring configuration, Seal configuration, Balanced or Unbalanced type etc. Pump manufacturer to decide the same along with seal manufacturer.

8.3.9 Seal life has to be guaranteed, taking into consideration all its components for 25000 hrs. If the seals fail before the completion of guaranteed period, the same should be replaced free of cost by the Supplier.

8.4 Shaft and Shaft Sleeve

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

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

8.4.3 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

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consecutive bearings must include a sufficiently large safety margin to satisfy this condition.

8.4.4 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.

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

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

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

8.4.8 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.

8.4.9 Shaft shall have a keyed joint at impeller hub. Threaded connection between impeller and shaft is not acceptable.

8.5 Coupling

8.5.1 The HT drive motor is excluded from the scope of supply. However, the Supplier shall supply coupling between pump & gear box, coupling between gear box & motor along with gear box.

8.5.2 Couplings shall be of flexible membrane type and shall not need any lubrication.

8.5.3 Couplings shall be dynamically balanced as per ISO 1940 G2.5. Balancing shall be done before slotting the key ways.

8.5.4 Couplings shall be suitable for accommodating axial movements and parallel offsets. The maximum permissible axial and parallel misalignment to be indicated in the coupling drawings.

8.5.5 Construction of the coupling shall be such that in case of membrane failure, no component of the coupling shall fly off while the equipment is in rotation

8.5.6 Membrane element shall be independently replaceable without requiring the replacement of the spacer.

8.5.7 All the nuts and bolts shall be with metric threads.

8.5.8 The Couplings shall be provided with adapter plates on both ends of spacer assembly, to facilitate removal of spacer assembly without dismantling the membrane packs

8.5.9 Gagging Screws shall be provided for Transportation and Installation of coupling. These Screws must be accessible from outside when the Coupling is fully assembled.

8.5.10 All the couplings shall be provided with over load washers designed adequately

8.5.11 A notch of 30x15x3 mm shall be provided on the periphery of each coupling hub for speed measurement.

8.5.12 Coupling halves shall be machine matched to ensure accurate alignment. Couplings and gears must have a rated capacity of at least 120% of the maximum potential power transmission requirement.

8.5.13 All rotating parts such as coupling shall be covered with suitable protective guards. Guards shall be easily removable type. If weight of the coupling is heavy (>40 kgs), provision of tapped hole should be incorporated in right place of hub to handle the same effortlessly.

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8.6 Base plate

8.6.1 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.

8.6.2 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.

8.6.3 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.

8.6.4 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.

8.6.5 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.

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

8.7 Bearings

8.7.1 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.

8.7.2 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.

8.7.3 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.

8.7.4 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.

8.7.5 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.

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8.8 Gearbox

8.8.1 Pump shall be driven by a gear box and shall have a service factor of 2 or better.

8.8.2 Gear Box shall be designed for continuous duty.

8.8.3 Gear Box design shall be such that it shall not impose any axial or radial forces either on pump bearings or on motor bearings.

8.8.4 Gear Box shall be in accordance with AGMA-420 or 421 or any internationally accepted standard.

8.8.5 Gearing shall be enclosed in an oil and dust proof gear case made of close grained cast iron or fabricated steel. The gear case shall be horizontally split. The gear case shall be of rigid construction to provide permanent alignment of rotating parts. The arrangement shall be such that it will be possible to fit gear case cover without disturbing the alignment of the shaft, gear and pinion

8.8.6 Gear Box shall be provided with integral piping for lubrication and cooling. One terminal point each for oil inlet and oil return, CW inlet and CW outlet in the form of ANSI flange, with counter flange bolts, gasket and nuts shall be provided.

8.8.7 If Gearbox requires cooling water, volume and pressure of cooling water is to be indicated in Technical Data Sheet. Cooling water data for gearbox cooling:

8.8.7.1 Inlet temperature: 38 DegC

8.8.7.2 Maximum Allowable Temperature increase: 10 DegC at the outlet

8.8.7.3 Inlet Pressure: 4 to 6 bar

8.8.7.4 Maximum Allowable Pressure Drop: $\leq$ 1.0 Kg/cm2.

8.8.8 Cooling water flow switch and sight glass shall be provided to monitor the flow of cooling water to Gearbox for each pump.

8.8.9 If heat exchanger is provided to cool gearbox then Temperature gauges and pressure gauges upstream and downstream, tube and shell side to be provided for each pump.

8.8.10 All RTD connections shall be terminated to Junction Box. Junction Box shall be provided along with Gear Box with 20% spare terminals.

8.8.11 Each bearing shall be provided with one capillary type dial thermometer of 160 mm dial size suitable for panel mounting with 5 meters capillary length. Thermometers shall be mounted on gauge board, to be fixed to the gear box by the vendor. Label shall be provided for each thermometer to indicate the purpose

8.9 Accessories

8.9.1 Expansion Joints

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

8.9.2 Pressure Gauges

8.9.2.1 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.

8.9.3 Provision for Vibration Monitoring:

8.9.3.1 Suitable provision/pads for mounting vibration sensors, Key phase sensors shall be provided on gearbox and pump. For each bearing there shall be provisions for Two (02) No's of Vibration sensors (X and Y Axis) for vibration measurement. Provisions

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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.

8.9.4 Temperature elements:

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

8.9.4.2 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.

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

8.10 Pump Control

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

8.10.2 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.

8.10.2.1 Alarm Signal

8.10.2.1.1 Bearing temperature high

8.10.2.1.2 Gearbox cooling water flow low (if applicable)

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

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

9. General Requirements

9.1 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.

9.2 Descriptions in the drawings, documents and in the displays shall be in English.

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

9.4 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.

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

9.6 Suitable drain connections shall be provided.

9.7 The equipment shall be suitable for stable continuous operation.

9.8 Service life: Entire pump except wearing parts shall be designed and fabricated for a minimum service life of 30 years of operation or 200,000 full load operating hours whichever is longer.

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

9.10 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.

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9.11 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.

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

9.13 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. Minimum shock factor for lifting lugs shall be minimum 2.0. The position of lifting lugs and reference dimension shall be shown on GA and/or outline drawings. NDT shall be conducted for lifting lugs. When any spreader bars are required for lifting and laydown, the Supplier shall provide spreader bar with equipment.

9.14 Equipment shall be fabricated as skid mount design as much as practical to minimize erection at the site.

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

9.16 Foundation bolts shall be provided with double nuts.

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

9.18 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.

9.19 The Supplier shall have responsibility for vibration control of the equipment train at the site and the unit's satisfactory performance, even if the foundation, driver are provided by the BHEL.

9.20 Supplier to quote for the Initial Spare parts (Mandatory Spares) for equipment.

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

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

9.23 Supplier to indicate the weights of components for handling.

9.24 The list of all Bought out items with makes and country of origin to be mentioned along with offer to be submitted.

9.25 Quality Plan to be submitted along with the offer.

9.26 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.

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

9.28 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.

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

9.29.1 Raw material inspection certificate
9.29.2 Internal test reports
9.29.3 Statutory certificates as required.

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

9.30.1 Relevant Standards
9.30.2 Specifications
9.30.3 Approved drawings
9.30.4 Data Sheets
9.30.5 Calibration certificate for all the measuring instruments
9.30.6 Supplier should also coordinate in getting the Material Dispatch clearance certificate and all types of Inspection Certificates from the end customer along with BHEL

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

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

9.33 The identification and numbering of equipment, systems, items, etc. of supply, as well as of all documents and drawings shall be in accordance with the VGB guideline RDS-PP (Reference Designation System for Power Plants - KKS system).

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

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

9.36 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.

9.37 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.

9.37.1 "Accepted without deviation and considered in scope of work" **[or]**
9.37.2 "Not considered in scope of work"

10. Packing

10.1 Packing shall be as per relevant product packing specification.

10.2 Cardboard containers shall be enclosed in a solid wooden container

10.3 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.

10.4 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

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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.

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

10.6 Packaging or shipping units shall be designed within the limitations of the unloading facilities of the receiving ports and the ship used. It shall be the Supplier's responsibility to investigate these limitations and to provide suitable packaging and shipping to permit transportation to site.

10.7 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.

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

10.8.1 Destination
10.8.2 Package Number
10.8.3 Gross and Net Weight
10.8.4 Dimensions
10.8.5 Lifting places
10.8.6 Handling marks and the following delivery marking

10.9 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

10.10 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.

10.11 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.

10.12 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)

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

10.13.1 Upright position
10.13.2 Sling position and center of Gravity position
10.13.3 Storage category
10.13.4 Fragile components (to be marked properly with a clear warning for safe handling)

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11. Supervision of Erection and Commissioning

11.1 The erection of Recirculation Pumps will be done by owner as per Erection & commissioning Manual and check List. However, the Supplier shall make one visit per boiler 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.

11.2 There will be one visit per boiler. Supplier shall include 10 working days per 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.

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

12. Exclusions

The following shall be exclusions in the scope:

12.1 Supply of main drive Motor.

12.2 Civil foundations.

12.3 Vibration monitoring system including sensors.

13. Inspection and Testing

13.1 Minimum Testing requirements to be considered are as below:

13.1.1 Hydrostatic test is to be conducted at 150 % of design pressure for duration of 30 minutes at operating temperature of 60 degC.

13.1.2 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).

13.1.3 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.

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

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

13.1.4.2 Impeller- DPT and MPI as applicable

13.1.4.3 Shaft- Ultrasonic (UT), DPT and MPI

13.1.4.4 Sleeve- DP and Hardness test/ Manufacturer's recommendation

13.1.4.5 Mechanical Seal- Manufacturer's recommendation.

13.1.4.6 Base Plate- Stress relieving of weld if applicable.

13.1.4.7 Replaceable Rubber liner- Shore Hardness, Class and Type certificate

13.1.5 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.

13.1.6 NPSH Test, Vibration test and Noise level test shall be witnessed at shop.

13.1.7 For surfaces with rubber lining Welding shall be visually inspected to verify the absence of rough area and unacceptable transition between surfaces which prevent

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the adequate adherence of rubber. The acceptance criteria shall be as per latest standard.

13.1.8 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.

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

13.1.10 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.

13.1.11 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.

13.2 General Inspection requirements to be considered are as below:

13.2.1 Supplier shall furnish written copies of shop production, fabrication and quality test procedures and drawings to be used for review by BHEL/end customer prior to manufacture. Inspection of above mentioned tests by BHEL representative at Supplier's works is envisaged.

13.2.2 The Supplier shall furnish performance test procedure along with standard. The test procedure shall be submitted for approval by BHEL.

13.2.3 Out of total Recirculation Pumps, One Number of Recirculation Pump will be inspected at the Supplier's works before dispatch or where the test facilities are available.

13.2.4 The Supplier shall conduct performance test for the remaining pumps and submit the reports.

13.2.5 A dynamic balancing certificates stating that the rotating assembly has been balanced dynamically shall be sent to BHEL within one (1) week of the successful completion of balancing.

13.2.6 Acceptance tolerance of actual versus guaranteed performance for capacity, head, efficiency and power absorbed shall be as per applicable standard.

13.2.7 Vibration levels shall be measured during shop running/performance tests.

13.2.8 Contract shaft seals shall be used during shop tests, unless the seal design is unsuitable for the shop-test condition.

13.2.9 Recirculation pumps shall not be released for shipment, until shop tests data and performance tests curves have been approved by BHEL/end customer.

13.2.10 Supplier should furnish performance guarantee as per applicable standard, guarantee for the design, manufacture, material and safe operation of the equipment.

13.2.11 BHEL shall witness the test at Supplier's works and a notice of minimum three (3) weeks shall be given for attending the inspection.

13.2.12 Supplier to arrange all calibrated gauges, Instruments during inspection.

13.2.13 Mechanical running and the performance test shall be carried out. Supplier to inform in advance the Motor rating for the shop test and inspection.

13.2.14 The performance test may be carried out using water at shop and shall be converted to the design condition.

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14. Painting

14.1 Surface Preparation: Blast Cleaning SA 2.5

14.2 Primer Coat

14.2.1 Zinc Epoxy
14.2.2 DFT= 80micron per coat
14.2.3 No of coats = 1.
14.2.4 Primer coat thickness 80 micron.

14.3 Finish Coat

14.3.1 Epoxy High Solid
14.3.2 DFT= 50micron per coat
14.3.3 No of coats = 2.
14.3.4 Coat thickness 100 micron.
14.3.5 Total DFT : 180 micron.

14.4 Color Code (based on DIN 2403:2007-05 & DIN 5381)

14.4.1 Base: Signal Orange, RAL: 2010
14.4.2 Lettering: Signal Black, RAL: 9004.

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

14.6 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.

15. Spares, Tools & Tackles

15.1 Start-up & Commissioning Spares

Start-up & Commissioning Spares shall be part of the main supply of the Recirculation 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".

15.2 Recommended Spares

Suppliers shall also furnish the recommended spares list along with the offer. Supplier shall provide a "Recommended Spare Parts List" which shall comprise of all items of the Initial Spare Parts List as well as other spares required for long term routine/planned and breakdown maintenance. Supplier shall indicate all details for each item of aforesaid Recommended Spare Parts List, such as Supplier's/ Original equipment manufacturers (OEM's) name and location, drawings, normal delivery period, quantity, service life, Supplier's/OEM's serial numbers and price etc. The format and content of the final spare parts list shall be agreed in the basic/detailed engineering phase. Then the final spare parts list shall be submitted by the Supplier to BHEL for approval not later than eighteen (18) months prior to the Scheduled Commercial Operation Date (COD) of the 1st Unit. The Supplier shall name OEM/ three (3) vendors with complete address for each of the spare parts.

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Supplier shall quote for the "Recommended Spare Parts List", however it shall not be considered for L1 evaluation, but these spares items shall remain available for order anytime during the first two (2) years commencing from COD of first unit, at the initial unit prices quoted in the offer as adjusted pursuant to the indexation mechanism approved by end customer. However, the end customer shall have the freedom to decide at its sole discretion to purchase spare parts either from OEM (according to quoted unit price as stated above) or directly from sub-vendors or from any other source.

15.3 Mandatory Spares:

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

15.3.1 Impeller assembly - 1 no. of each type
15.3.2 Casing liners-If applicable – 1 no. of each type
15.3.3 Seals - 1 no. of each type
15.3.4 Bearings - 1 no. of each type
15.3.5 Oil Cups-If applicable – 1 no. of each type
15.3.6 Shafts & Sleeve- 1 no. of each type
15.3.7 Pressure gauge- 1 no. of each type
15.3.8 Bearing Temp Transmitter- 1 no. of each type

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.

15.4 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".

16. Performance Guarantee

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

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

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

16.3 The Supplier shall ensure a design of the equipment to achieve an average target availability of 90%.

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

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

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

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

16.8 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.

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

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

17. Bid Evaluation Criteria for Power Consumption

17.1 Power Guarantee

Supplier to specify the guaranteed Shaft power per Pump operating at the duty point in their offer

17.2 Bid evaluation criteria for power consumption:

Power consumption quoted by Supplier shall be limited to the ceiling value specified below.

Ceiling value for Shaft power of Recirculation pump (refer variant table)

In case, Guaranteed Shaft power offered by the Supplier exceeds the ceiling value specified above, his bid price will be loaded for excess power consumption as per the formula given below.

Adjustment factor for excess power consumption in USD = (GPC-CV) X PL X No's of Working pumps (as per variant table)

GPC- Guaranteed Shaft Power Consumption quoted by Supplier in KW

CV- Ceiling Value for Shaft Power Consumption

PL- Power Loading @ 4060 USD/KW

Exchange rate as applicable on price bid opening date will be considered.

No Price advantage apart from NIL Power Loading will be given if Guaranteed Power consumption offered is less than the ceiling value.

18. Liquidated Damages for Power Consumption

If actual shaft Power Consumption during prove out (or) PG Test operating at the duty point exceeds the value guaranteed by the Supplier, liquidated damages for shortfall in performance shall be deducted from contract price as per the formula given below

Liquidated damage deductible in USD per pump = (GPC-APC) X P X No's of Working pumps (as per variant table), where

- GPC- Guaranteed Shaft Power Consumption quoted by Supplier in KW
- APC- Actual Shaft Power Consumption in KW
- P- Penalty @ 4060 USD per KW

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19. Warranty

19.1 The warranty period shall begin on the date of taking over by end customer or date of issuance of the provisional acceptance certificate for the unit (whichever occurs first) and shall end after twenty-four (24) months. Provided that the successful Supplier shall extend the provisions of this warranty to cover all repaired and replacement parts furnished under the warranty obligations hereunder, subject to the warranty period for the same being for a period of 24 months from the date on which replacement or renewal work is completed.

19.2 In case of failure of the equipment to meet the guarantee, BHEL/end customer reserves the right to reject the equipment. However, BHEL/end customer reserves the right to use the equipment until new equipment supplied by Supplier meets the guaranteed requirement .

20. First fill of Consumables

20.1 Supplier's scope shall also include supply and filling of all consumable items for operation up to COD including top up requirements at the time of issuance of PAC/declaration of COD. All lubricants proposed for the plant operation shall be suitable for all operating and environmental conditions that will be met on site consistent with good maintenance procedures as instructed in the maintenance manuals.

20.2 Detailed specifications for the lubricating oil, grease, other consumables if any, including items qualities and quantities required per month of the plant operation shall be furnished. On completion of erection, complete list of bearings/equipment giving their location and identification marks shall be furnished to end customer along with lubrication requirements. For each type and grade of lubricant recommended, Supplier shall list at least three equivalent lubricants manufactured by alternative companies.

21. Conflict

Supplier's equipment shall be designed for and shall meet the service, performance and minimum level of quality requirements specified. Supplier shall be solely responsible for advising end customer in writing of any conflicts between the specifications and Supplier's design, including performance and levels of quality. Supplier agrees that its obligations, liabilities and warranties shall not be diminished or extinguished due to its meeting the requirements of the Specification.

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22. Documentation

22.1 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.

22.1.1 Sectional Assembly, P&ID diagram
22.1.2 Performance curve
22.1.3 Terminal point details.
22.1.4 General Arrangement with civil loads and pocket details.
22.1.5 Rotor GD2 (kg-m2)
22.1.6 Connecting coupling technical data.
22.1.7 Torque Vs Speed curve
22.1.8 Calculation of Motor rating, Bearing capacity and coupling selection.
22.1.9 Bill of material along with ASTM or its equivalent materials.
22.1.10 Overall space and headroom requirement during Erection, maintenance of pump.
22.1.11 Erection, Operation & Maintenance manual with lubrication schedule
22.1.12 Procedure for shop / site performance tests
22.1.13 Time schedule for delivery.
22.1.14 Quality Assurance Plan.
22.1.15 Make of all bought out items.
22.1.16 Deviation list
22.1.17 Spares list.
22.1.18 Hoist / Crane requirement.
22.1.19 Reference list of similar projects executed.
22.1.20 List of proposed makes and vendors
22.1.21 Training program and schedule for BHEL & customer personnel
22.1.22 Equipment maintenance schedules

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22.2 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.

22.2.1 Duly filled technical datasheet.
22.2.2 General arrangement drawings indicating dimension and civil loading details.
22.2.3 Motor Data.
22.2.4 Recommended repair procedure etc.
22.2.5 Operation and maintenance manuals.
22.2.6 Assembly & Dis-assembly sequence shall be submitted as a separate document prior to the submission of the Operation and Maintenance Manual.
22.2.7 Erection schedule and component list.
22.2.8 Successful Supplier shall submit Calculation for HT Motor power requirement for sizing HT Motor within 2 weeks from the date of ordering.
22.2.9 The following performance curves of the pump shall be submitted:
22.2.9.1 Flow v/s Head
22.2.9.2 Flow v/s NPSH
22.2.9.3 Flow v/s Efficiency
22.2.9.4 Flow v/s power consumption
22.2.9.5 Torque vs. speed curve for Motor selection
22.2.10 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.

All necessary GA drawings, sections, sub-assembly drawings, specifications of main and sub components and necessary set of operation & maintenance manual as asked by BHEL/end customer must be furnished by Supplier in soft and hard copy forms. For all documents softcopy format shall be searchable pdf, however in addition all drawings, diagrams like P&IDS shall be supplied in ACAD or other editable format and all lists in Excel format. Further break up of technical documents will be discussed during finalization of the purchase contract.

Unless agreed otherwise, Ten (10) hard copies and five (05) sets of electronic copies of all documents are to be submitted in the English language. Electronic Copies shall be submitted in primary original data format (e.g. DOC, XLS, DWG) as well as in a printable non-proprietary document format (e.g. PDF). P&IDs & drawings shall be submitted as DWG files and PDF files. Supplier to ensure submission of hard copies as per end customer requirement for all engineering drg/doc and for all subsequent revisions along with a soft copy through email to concerned project team. All the engineering related information shall be furnished in soft form to BHEL.

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Variant Table

S.NO	ITEM DESCRIPTION	QUANTITY	UNIT	MATERIAL CODE	VAR. No
1	PUMP-CASING LINERs	2 No. of each type.1No. shall be complete replacement of one pump	EA	FP9760317516	Var-01 Var-02 Var-03
2	SEALS OF ALL TYPE	2 Set of each type	SET	FP9760317524	Var-01 Var-02 Var-03
3	TRANSMITTER/GAUGES/SWITCHES ETC. ALONG WITH RELEVANT ACCESSORIES	2 no. of each type, along with accessories	SET	FP9760317532	Var-01 Var-02 Var-03
4	TEMPERATURE ELEMENT(RTD/THERMO-COUPLE) WITH THERMOWELL	2 no. of each type, range and immersion length	SET	FP9760317540	Var-01 Var-02 Var-03
5	IMPELLER FOR SLURRY RECIRCULATION PUMP	1 No of each type and Size	EA	FP9760317052	Var-01

Note to supplier regarding mandatory spares:

23. 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.
24. Casing liners shall be a complete replacement of liners in the supplied pump, if applicable.
25. Set of seals shall include Mechanical seal, oil seals, wear rings at impeller location, oil thrower & oil guards in the entire scope of supply.
26. Set of Transmitters along with accessories shall include all the transmitters and its accessories where ever used in the entire scope of supply.
27. Temperature elements with Thermowell shall include all temperature elements where ever used in the entire scope of supply.
28. Local gauges along with accessories shall include all local gauges where ever used in the entire scope of supply.

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29. ANNEXURES

29.1 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
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		:	*

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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		:	*

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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

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NAME ----------

DESIGNATION ----------

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29.2 Annexure-2, Schedule of guarantees

S.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	:	≥14000 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.

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29.3 Annexure-3, Reference list (at least two power plant details)

S.No	Project Name , Customer & Plant capacity	Coal fired Yes/No	Wet Limestone Based FGD Yes/No	Model	Capacity m^3/hr.	Head m	Speed rpm	Year of Commissioning	Qty
1									
2									
3									

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29.4 Annexure-4, List of Deviations

S.No	Clause No	Page No	Description of Deviation

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29.5 Annexure-5

29.5.1 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.	Manufacturing Time	1
8.	Approximate weight of each skid	1
9.	Reference plant details	1
10.	Required Electric power & other Utility List	1
11.	Deviation List	1
12.	General Assembly Drawing	1
13.	Pump and Motor Sizing Calculation	1
14.	Cross-sectional Drawing	1
15.	Sub-Vendor List	1
16.	Scope of Supply	1
17.	Quality Plan	1
18.	Spare List (Mandatory, Recommended)	1
19.	Start-up & Commissioning Spares	1
20.	List of Special Tools	1
21.	Delivery Schedule	1
22.	Test Arrangement & Test procedure	1
23.	Hoist/Crane requirement	1
24.	P & I Diagram	1
25.	Catalogue	1
26.		

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29.5.2 **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.	Manufacturing Schedule	1	2 weeks after contract
15.	Progress report	1	Every month
16.	Pro-forma Packing List	1	2 months prior to shipping
17.	Approximate weight of pump	1	2 months after contract
18.	Required Electric power	2	2 weeks after contract
19.	Pump and Motor Sizing Calculation	1	2 weeks after contract
20.	Material Test Certificates	2	In 2 weeks after test
21.	Pre Commissioning Check List	2	4 months after contract
22.	Scope of Supply	2	2 weeks after contract
23.	Quality Plan	4	1 month after contract
24.	Operation and Maintenance Manual	Hardcopies and soft copies as mentioned	4 months after contract
25.	Spare List (Mandatory, Recommended)	1	1 month after contract
26.	Start-up & Commissioning Spares	2	1 month after contract

S.No.	Description	No of copies After award of contract	Delivery Time
27.	List of Special Tools	1	1 month after contract
28.	Delivery Schedule	1	2 weeks after contract
29.	Test Arrangement & Test procedure	2	1 month after contract
30.	T-S curve	2	2 weeks after contract
31.	P & I Diagram	2	2 weeks after contract
32.	Catalogue	2	2 weeks after contract

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RECORD OF REVISIONS

Rev. No.	Date	Revision Details	Revised by	Approved By
01	30.12.19	Technical parameters of Variant 02 added for Bhadradri TPP, 4x270MW. Scope of supply revised.	ASK	MSR
02	07.02.20	Mandatory spares for Bhadradri TPP, 4x270MW added in variant table.	ASK	MSR
03	13.02.20	Technical parameters of Variant 03 added for Bhusawal, 1x660MW.	ASK	MSR
04	15.04.20	Technical parameters of Variant 03 revised for Bhusawal, 1x660MW based on BAP input.	ASK	MSR
05	27.07.21	Technical parameters of Variant 01 & Variant 02 revised for Yadadri TPP, 5x800MW and Bhadradri TPP, 4x270MW Project based on BAP input.	JD	SK
06	24.08.21	Sl No .05 added in Variant Table for Yadadri TPP, 5x800MW.	JD	SK
07	16.09.21	Var.01 added in Sl No .03 & 04 in Variant Table for Yadadri TPP, 5x800MW.	JD	SK

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