TECHNICAL SPECIFICATION OF GEAR BOX WITH TURNING GEAR MOUNTED ON GEAR BOX FOR STG SET

APPLICABLE STANDARD : **AGMA 6011 - I 03**

PURPOSE : To function as a speed reducer between high speed steam turbine and Generator.

1) TECHNICAL AND GENERAL REQUIREMENTS :

a) Gear box shall be **Double helical** type. **Split Gear wheel is Not Acceptable**.

b) Maximum permissible Noise Level should be within **85 dB(A)** at a distance of 1m.

c) The gearbox shall be able to withstand 20% of overspeed for a period of minimum five (5) minutes. The supplier should confirm the same.

d) Gearbox and Turning gear shall be designed considering the following Voltage and Frequency variations. The supplier should confirm the same.
- Voltage : ± 10%
- Frequency : ± 5%
- Combined Voltage & Frequency : ± 10%

e) For general specification of gear box refer to TC 51835 **Rev 02**. If any conflict between TC 51835 & TC 61699, TC 61699 is valid.

f) Annexure to TC 61699 (6 sheets) should be completely filled and enclosed with offer.

g) **Reference list should be as per BHEL format**.

h) Gearbox footprint details given in preliminary drawing are to be final and not to be changed after ordering.

i) Turning gear shall be fully automatic type i.e. engagement and disengagement shall be automatic. Soft starter should be supplied as a panel wired with Timer, Transformer, connectors etc.

j) Each journal bearing should be provided with 2 nos of 3-wire Duplex RTDs. Each side of Thrust bearing should be provided with 2 nos. of 3-wire Duplex RTDs.

2) ACCEPTANCE OF THE OFFER : **The offer is liable to be rejected if the following data are not furnished** :

a) The reference list with at least two Gear boxes similar to offered size having comparable rating, speed ratio and service factor, and under operation for more than two years.

b) Preliminary gear box drawing, foundation details and torsional analysis data (Preliminary geometry of pinion and Gear shafts).

c) Confirmation that pinion damped critical speeds are above 120% of operating speeds under no load to full load condition.

d) Confirmation to any of the requirements of the specifications (TC 51835 & TC 61699)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gear box output power = 26260 kW.

Gear Service factor = 1.6 (Minimum)

Input speed = 6300 RPM

Output speed = 1500 RPM

Trip speed = 6930 RPM.

Minimum yield strength of Turbine Rotor = 540 N/mm^2

Short circuit factor = 6.0

Lube oil to be used = ISO VG46 Grade

Type of Thermoelement = 3-Wire duplex RTD, Calibrated as per DIN 43760

The Turning gear shall be designed to meet the following requirements:

Turning gear speed = 150 RPM (approx.)

GD^2 value of Turbine Rotor (Referred to turbine speed) = 605 $Kg\text{-}m^2$

GD^2 value of Generator Rotor (Referred to Generator speed) = 12652 $Kg\text{-}m^2$

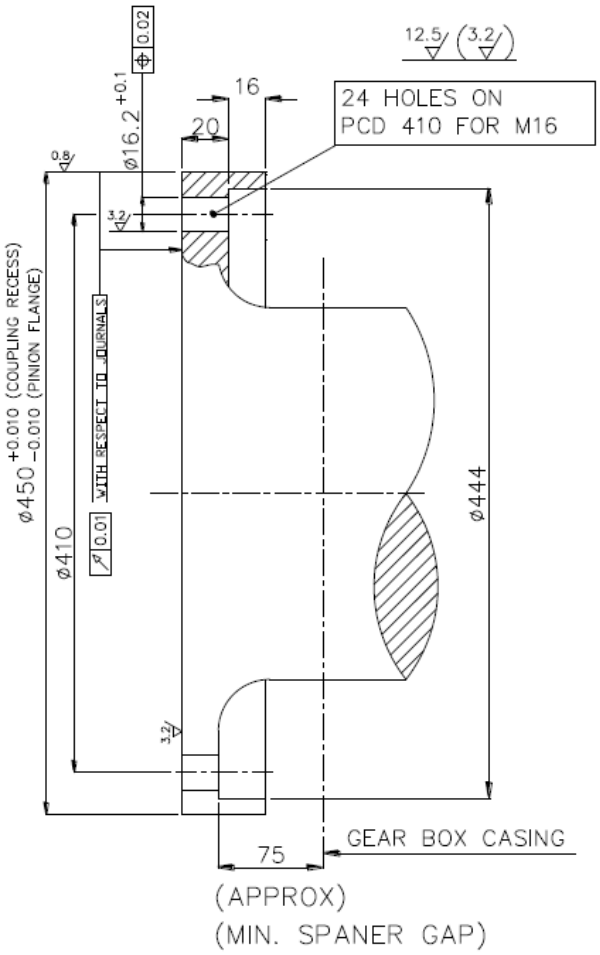
Break away torque of Turbine rotor = 40 Kg-m ($\mu = 0.05$)

Break away torque of Generator rotor = 170 Kg-m ($\mu = 0.05$)

4) **Coupling between Turbine and Gear box**

The coupling is flexible membrane type, non-lubricated and with a spacer, and is in BHEL scope. The end details of pinion shaft shall be as follows:

PINION SHAFT END DETAILS



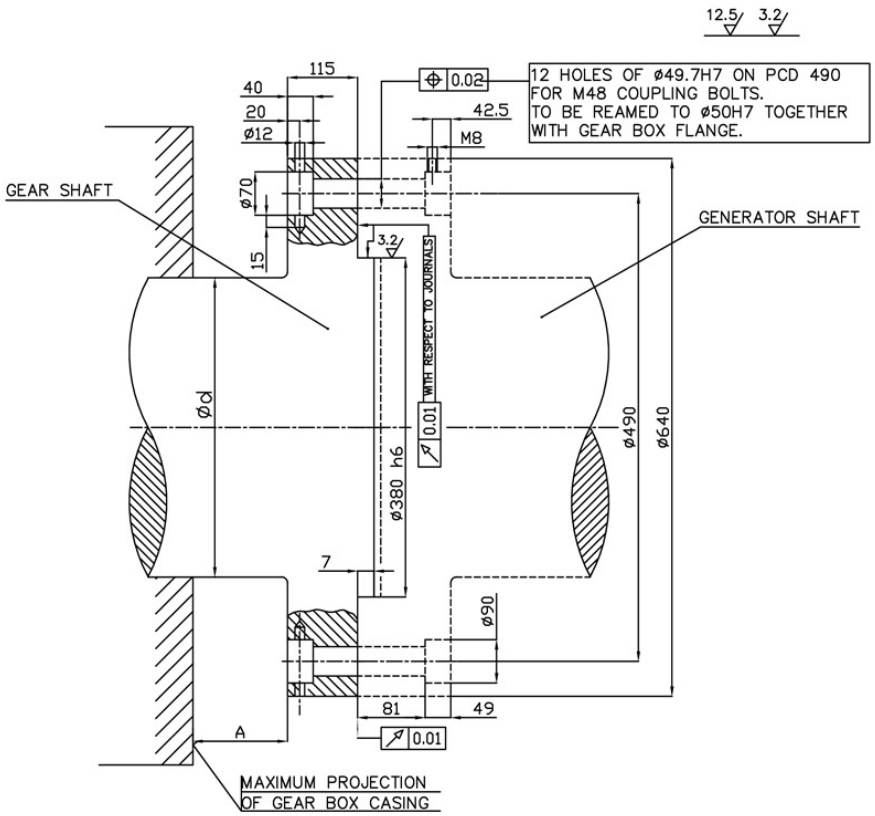
NOTE 2: For rotor dynamics of gear box consider the following coupling values:
The center of gravity location and half coupling weight for input coupling between turbine and gear box are 50 mm and 120 Kg respectively.

5) **Coupling between Gear box and Generator**

The coupling is rigid coupling. As generator has no thrust bearing, axial location for the same is to be provided in the gearbox itself. The end details of gear shaft shall be as shown below:

Gearbox locating key shall be under gear shaft so that no lateral movement of gear shaft takes place during operation.
The end details of Gear shaft shall be as shown below.

GEAR AND GENERATOR SHAFT END DETAILS



NOTE: IT IS PREFERABLE TO HAVE A>3d

NOTE 1) : **Minimum tensile yield strength of gear shaft (flange) material must be 550 N/mm^2**

RECORD OF REVISIONS

REV.NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	**07.12.2020**	**NEW**	**TMK**	**PATIL**

TECHNICAL SPECIFICATIONS OF GEAR BOX WITH TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET

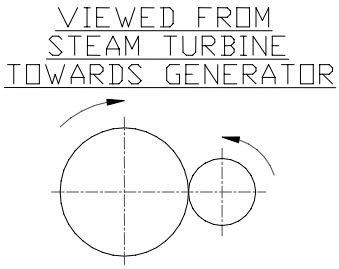
Applicable standards : **AGMA 6011-I 03**

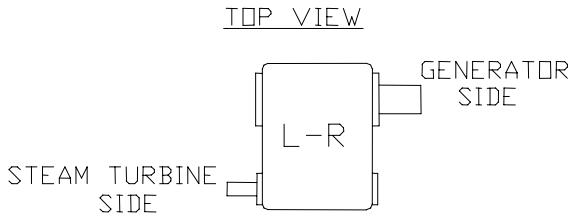
1. PURPOSE : To function as a speed reducer between high speed steam turbine and generator.

2. TYPE OF GEAR BOX : Parallel shaft with horizontal offset.

3. Gear box shall be capable of operating continuously from 0% to 100% power. Gearbox shall be designed to meet the requirements given in the job specification.

4. a) Direction of rotation of input shaft as viewed from driving machine : Counter Clockwise.
b) Direction of rotation of output shaft as viewed from driving machine towards driven machine : Clockwise.
c) Location of gear box output shaft when viewed from driving machine towards driven machine is as follows.





5. a) Teeth of gear wheel and pinion : Hardened and ground.
b) Peripheral speed : < 150 m/sec

6. a) Gear box casing shall be horizontally split.
b) Provision shall be made for fixing of input and output coupling guards.

7. The shaft end details for mounting the couplings are given in job specification.

8. NOISE LEVEL :

Maximum permissible noise level is given in job specification.

9. VIBRATIONS :

a) Shaft vibrations should be within limits specified by AGMA.
b) Casing vibrations should be within limits specified by VDI 2056.

10. INSPECTION AND TESTS :

Functional testing is as per AGMA. Quality plan and scope of tests to be submitted along with the offer.

Gear box shall meet the Inspection/testing requirements as indicated below:

	Reqd.	Lloyd's Witness	Observed	Test log
Material Tests on Pinion, Gear and Shafts	✔			✔
Shop Inspection	✔			
Cleanliness Inspection	✔		✔	
Hardness Verification Inspection	✔		✔	✔
Dismantle – Reassembly Inspection	✔			
Contact Check tape lift	✔		✔	✔
Journal runout Check	✔			✔
100% magnetic particle inspection of Gear and Pinion	✔			✔
Rotor balancing machine sensitivity check	✔		✔	✔
Residual Unbalance check	✔		✔	✔
Final assembly maintenance & running clearance	✔			
Mechanical run test	✔			✔
Full Torque, slow roll Test (See Note 1)				
Oil system cleanliness	✔		✔	
Sound level test	✔			✔
Use shop lube system	✔			
Use job vibration probes, etc				
Oil system casing joint tightness	✔		✔	

Witnessed means that a hold shall be applied to the production schedule and that the inspection or test shall be carried out with BHEL or its representative in attendance. For mechanical running or performance tests, this requires written notification of a successful preliminary test.

Observed means that the purchaser shall be notified of the timing of the inspection or test: however, the inspection or test is performed as scheduled, and if BHEL or its representative is not present, the vendor shall proceed to the next step.

a) The no-load test shall be carried out by driving the pinion shaft end in the direction as specified.

b) During mechanical run test of Gearbox, half coupling weights acting on pinion and gear shafts have to be simulated. Simulated weight is to be balanced to Q0.67.

Note 1: Furnish specific confirmation along with test procedure.

11. <u>TURNING GEAR :</u>

Turning gear with driving motor is to be supplied along with gear box. This is to be mounted on the high speed shaft and towards generator side. This is to be designed as per the requirements given in the job specification and as follows:

a) Speed of high speed shaft during turning gear operations is 150 rpm (approx.).

b) Engagement : Engagement is by hand and disengagement is automatic by speeding up the turbine. Disengagement should also be possible by reversing the electric motor. Turning gear is to be provided with 2 limit switches for signaling engage disengaged positions. A wiring diagram for the limit switches and indicators shall be submitted after placement of order.

c) Turning gear driving motor should be totally enclosed and fan cooled type.

Voltage	:	415 ± 5%
Frequency	:	50 Hz ± 3%
Type of starting	:	Direct on line
Protection type	:	IP55
Insulation class	:	B

Motor data shall be filled in the format on sheet 7 of this specification

d) Turning gear shall be provided with a hand wheel for manual turning.

12. The temperature rise of oil should not be more than 15 to 20^0 C with inlet oil temperature being 40^0 C to 50^0 C.

Pressure of oil	:	0.9 to 1.5 atg (app)
Max. ambient temperature	:	50^0 C
Environment	:	Humid and tropic

Lube oil connections should preferably be provided on left side of gearbox (when viewed from driving machine to driven machine). Lube oil inlet and drain connections shall be terminated with counter flanges as per ANSI B16.5. Surfaces coming in contact with oil should not be painted and to be cleaned and preserved properly. Oil inlet flange is stainless steel, outlet flange is carbon steel.

13. <u>GUARANTEE PERIOD :</u> Gear box is to be guaranteed for minimum operating hours of 10,000 from the date of commissioning of gear box at site.

14. Data to be supplied along with the offer :

a) Preliminary drawings of gear box.
b) Preliminary torsional analysis data.
c) Efficiency of gear box at 100%, 75%, 50%, 25% load.
d) Oil quantity required for gear box lubrication in m^3/hr.
e) Filled in Special Purpose Gear data sheets.
f) Materials used for different parts of gear box (gear wheel, pinion, casing, etc.)
g) Weight of Gear box, gear wheel and pinion shafts & size of bearings.
h) Reference list of similar gear boxes and supplied earlier.
i) Quality plan
j) Testing / Inspection procedure
k) Special requirements
l) Confirmation that pinion damped critical speeds are above 120% of operating speed under no load to full load condition.
m) Item wise price is to be given for the following :
   i) Gear box
   ii) Turning gear with driving motor
   iii) Spares for two years operation.
   Set of high speed shaft radial bearings.
   Set of low speed shaft radial bearings.
   Set of thrust bearing.
   Set of oil seals
   iv) Set of pinion shaft & Gear shaft including wheel.

15. Data to be supplied after placement of order within 15 days :

a) Final data sheets.
b) Final torsional analysis data of Gear box like GD^2 values, spring constants and geometry for pinion and gear wheel shafts to calculate the torsional critical speeds of the system.
c) Dimensional drawing of Gear box for approval.
d) Turning gear motor data sheet as per the format on sheet 7 of this standard.
e) Report on Rotodynamics analysis of pinion and gear shafts.

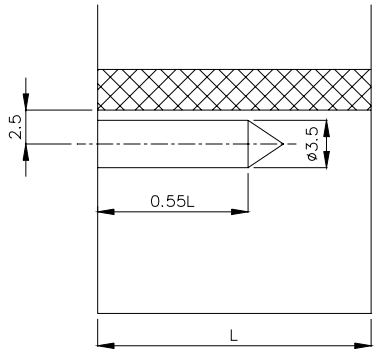
16. Data to be supplied after placement of order within two months :

a) Mounting lengths for vibration probes.
b) Alignment values for gearbox and operating instructions.

c) General wiring diagram for the turning gear showing limit switches and indicators.
d) Wiring diagram for thermo elements provided at gear box bearings.
e) Three hard copies and one Floppy copy of final (Approved) Gear Box out line drawing and Gear Box Assembly drawing showing all ordering details for spare parts.
f) 13 copies of operating and maintenance instructions for Gear box and Turning gear.
g) Operating and maintenance instructions for Gear box and Turning gear in computer file (CD).

17. SCOPE OF SUPPLY :

a) Gear box with Bimetallic thermometers (one per bearing for measuring the bearing oil temperature).
b) Provision shall be made for vibration pick-ups of Bentley Nevada make (two radial probes, each at 45° with horizontal, per journal bearing and one axial probe for each thrust bearing).
c) All connections should be NPT 3/4″ and holes are to be plugged and shaft portion to be polished.
d) Provision shall be made in the journal bearings for pencil type RTD's as shown below.



e) Turning gear with driving motor and necessary accessories like starting switch etc.

g) **Instrumentation :** 3-wire duplex RTDs (Platinum 100 Ω at 0°C, Calibration as per IEC 751) shall be provided (one per journal bearing and one on each side of each thrust bearing). They shall be wired to a common junction box mounted on the gear box. Junction box shall be in the supplier's scope. A wiring diagram for the RTD'S shall be provided by the supplier.

18. PAINTING, PRESERVATION AND PACKING

Supplier shall follow the following minimum painting, preservation and packing instructions for gear unit:

a) Exterior surfaces, except for machined surfaces, shall be given one coat of the epoxy based paint. The paint shall not contain lead or chromates. The standard shade of manufacturer is acceptable unless otherwise specified in our order.

b) Exterior machined surfaces shall be coated with a suitable rust preventive.

c) The interior of the gear unit shall be clean, free from scale, welding spatter and foreign objects and sprayed or flushed with a suitable rust preventive that can be removed with solvent. The rust preventive shall be applied through all openings while the gear unit is slow-rolled.

d) Internal steel areas of bearing housings and carbon steel oil systems, auxiliary equipment (piping) shall be coated with a suitable oil-soluble rust preventive.

e) Each unit shall be properly packed with adequate cushioning material to withstand transit damage. The packing shall be seaworthy.

MOTOR DATA SHEET

ALL MOTORS		1	MOTOR NUMBER				
		2	DRIVEN EQUIPMENT				
		3	DUTY				
		4	MANUFACTURER				
		5	TYPE				
		6	FRAME DESIGNATION				
		7	KILOWATT OUTPUT (KW)				
		8	VOLTAGE (V)				
		9	FULL LOAD AMPS (A)				
		10	FULL LOAD SPEED (RPM)				
		11	ENCLOSURE				
		12	MOUNTING				
		13	INSULATION CLASS				
		14	AMBIENT TEMP. / TEMP RISE (^{o}C)				
		15	APPLICABLE CODE				
		16	FULL LOAD TORQUE (N-m)				
		17	STARTING TORQUE AS %OF F.L. TORQUE				
		18	EFFICIENCY AT 100% LOAD (%)				
		19	EFFICIENCY AT 75% LOAD (%)				
		20	ROTATION VIEWED FROM NON-DRIVING SIDE				
		21	BEARING TYPE NO.				
		22	TYPE OF LUBRICATION				
		23	COUPLING / PULLEY				
		24	WEIGHT (Kg)				
		25	CABLE SIZE / TYPE				
AC MOTORS	SQ CAGE	26	FUSE / CONNECTION / NO.OF TERMINALS				
		27	FREQUENCY				
		28	NO. OF POLES				
		29	LOCKED ROTOR CURRENT (A)				
		30	LOCKED ROTORE WITHSTAND TIME - HOT (Sec)				
		31	" - COLD (Sec)				
		32	STATUS / ROTOR TIME CONSTRAINTS (Min)				
		33	POWER FACTOR AT 100% LOAD				
		34	" 75% LOAD				
		35	SECONDARY AMPS AT FULL LOAD				
		36	SECONDARY VOLTAGE				
		37	SECONDARY OHMS				
		38	BREAKDOWN OR PULL OUT TORQUE %				
	SYCH	39	RATED FIELD CURRENT				
		40	RATED EXCITER VOLTAGE				
		41	RATED POWER FACTOR				
		42	PULL IN TORQUE % OF FULL LOAD				
D.C		43	TYPE OF WINDING				
		44	SHUNT FIELD CURRENT				
ALL FEATURES		45	SPACE HEATERS - WATTS / VOLTS				
		46	TWO SPEED MOTORS - NO. OF WINDINGS				
		47	" - TORQUE				
		48	GD^2 OF LOAD (Kg/m^2)				
		49	GD^2 OF MOTOR (Kg/m^2)				
		50	THRUST - UP/DOWN (Kg)				
		51	STARTING TIME				

RECORD OF REVISIONS

REV NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	11-02-1998	NEW	N.S.N	B.V.S.N.S
01	27-02-2002	a) Revision at point 3 b) Revision at point 8 c) Changes in Inspection and testing at point 10 d) Revision at point 11 e) Revision at point 14 f) Points 15(e) & 16(g) added g) Revision at point 17	G.R.RAO	C.N.V.R
02	31-03-2007	a) Gearbox standard changed from G92 to I 03 b) provision for Axial probes is removed	G.R.RAO	C.N.V.R

Financial Criteria for Pre-qualification

The minimum average annual financial turnover of the supplier during the last 3 financial should not be less than Rs.30 Lakhs and positive net worth as per latest balance sheet.

Vendors shall enclose the last three financial years balance sheets and Profit & loss statements duly audited and certified by Charted Accountant.

In case of final audited balance sheet / Profit & Loss statement for the last year is not available, provisional statement for the same duly certified by Charted Accountant must be submitted.

In case audited financial statements have not been submitted for any of three years as indicated above, then the applicable audited statements submitted by bidders against the requisite three years will be averaged for three years i.e total divided by three.

Other incomes shall not be considered for arriving at annual financial turnover / sales. For evaluation purpose, only revenue from operations shall be considered.

PRE-QUALIFICATION CRITERIA			Dt:		
Gear Box for Steam Turbine					
S.No.	**BHEL Requirement**		**Vendor's Confirmation**	**Deviation if Any**	**Remarks**
1	All the suppliers need to submit this document i.e. titled pre-qualification criteria and furnish required information along with offer.				
2	a)	Name, address, e-mail id, contact no.etc. of manufacturer of Gear Box			
	b)	Name, address, e-mail id, contact no. etc. of authourised agency / trading house quoting on behalf of manufacturing company. In case offer is received from authourised agency / trading house, the following requirements shall be full filled. i) Valid letter of authorisation and copy of agreement to be enclosed with offer. ii) The offer shall be either from the authorised agency or from the manufacturer directly. In case of BHEL receiving offer from both, then offer from manufaturer will only be considered. Offer from an unauthorised agency / entity on behalf of any vendor shall be summarily rejected. iii) Name, address, e-mail id, contact no.etc. of entity on whom order to be released in case of L1 shall be clearly indicated.			
3	Supplier to confirm/provide the following criteria/documents for evaluation of offer.				
	(a)	Supplier shall furnish minimum 02 number of customer reference details for past tract record.The offered gearbox model shall be of proven design and shall be from the gear box manufacturer's existing regular production range. Gear box model offered shall be identical or validity similar in terms of power rating, Pinion speeds, Gear ratio, mechanical design, materials as compared to at least one unit designed, manufactured, tested and supplied from the proposed manufacturing plant, in the last ten years and the reference unit shall have completed one year of satisfactory operation at site on a continuous duty basis without any major over haul as on the date of issue of inquiry. Vendor shall fill up the experience record format for the offered model of the Gearbox & submit along with the offer.			Submit Past Track Record (PTR)
	i)	Date of supply & commissioning			
	ii)	Whether one year of field operation completed after commissioning as on bid due date.			
	iii)	Purchaser' s Name, Address, Contact No. & email ID			
	iv)	Service: Turbogenerator / Boiler feed pump drive			
	All the above criteria 3(a) (i) to 3(a) (iv) must be combinedly met by the vendor.				
	Suppliers having experience in Turbogenerator sets of Power plant and Turbo-compressors of Oil & Gas areas shall be considered.				
	Note : All the documents shall be furnished only in English. Documents furnished in other langauges will not be considered for further evaluation.				

Vendor's Signature with Seal

	(b) BHEL reserves the right to cross verify with the above such customers including overseas customers with a copy to the supplier and satisfy itself with reference to the claims of the supplier. If the information furnished by the supplier is not found satisfactory, the offer will be technically rejected.			
4	Offers without the requirement as above 3(a) & 3(b) will not be technically evaluated by BHEL. Further, no correspondence in this matter will be entertained.			
5	The vendors should furnish the detailed process of manufacturing and testing procedures along with the offer.			
6	List of BHEL qualified bidders shall be forwarded to BHEL's End Customer for their review and approval. The list finalized by BHEL's End Customer shall be final and binding.			
7	BHEL team may carry out vendor evaluation/assesment(incase of a new vendor)by a visit to vendor works for qualifying /rejecting the technical bid based on the findings of the visit.			
8	Vendors to submit their bid in 2 - part system i.e. Part-I shall consists of Pre-Qualification Criteria along with the required documents and Techno-Commercial Bid. Part-II shall consists of Price Bid. Offers failing to meet prequalification part will not be considered for further evaluation.			

Vendor's Signature with Seal

SPECIAL INSTRUCTIONS FOR Gear Box for Thermax Project - GeM

1. **Inspection by** BHEL appointed TPI and charges to BHEL account.
2. Please follow the link >> https://dipp.gov.in/public-procurements for all circulars. Evaluation will be done accordingly.
3. The material is required for Thermax Limited and material shall be dispatched to Thermax Limited Assam.
4. Guarantee/Warranty as follows "Warranty period within which supplier is liable to rectify/repair/replace the equipment at his cost for any defect/default in the performance, shall be 30 months from the date of 100% supply completion or 24 months from the date of successful performance testing carried out at site, or completion of 8000 Hrs working after successful commissioning, whichever is earliest. At the end of the warranty period, the supplier's liability ceases except for latent defects. In respect of goods supplied by sub-suppliers to the supplier where a longer guarantee (more than 24 months) is provided by such sub-suppliers, the purchaser shall be entitled to benefit of such longer guarantees."
5. Vendor acceptance subject to end customer approval.
6. Technical PQC & Financial PQC shall be submitted.
7. Delivery shall be 6 months from the date of PO.
8. Quality Plan shall be submitted after placement of PO for BHEL approval.

Supplier Declaration:

I _____(Supplier Name) declare that the above points are noted and Confirmed while submitting the quotation.

Authorized Signature & Stamp
(_____) Vendor Name