

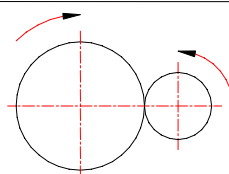
BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51834
		REV. 01
		PAGE 1 OF 8

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

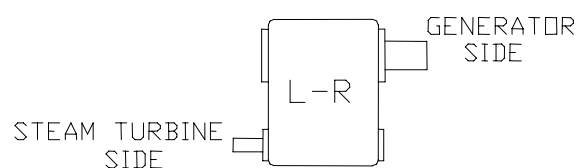
Applicable standards : **API 613 - 1995**

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.

VIED FROM
STEAM TURBINE
TOWARDS GENERATOR



TOP VIEW



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.

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		REV. 01
		PAGE 2 OF 8

8. NOISE LEVEL :

Maximum permissible noise level is given in job specification.

9. VIBRATIONS :

- a) Shaft vibrations should be within limits specified by API 613.
- b) Casing vibrations should be within limits specified by VDI 2056.

10. INSPECTION AND TESTS :

Functional testing is as per API 613. 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.

FORMAT
TD-202
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BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51834
		REV. 01
		PAGE 3 OF 8

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. **TURNING GEAR :**

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 20⁰ C with inlet oil temperature being 40⁰ C to 50⁰ C.

Pressure of oil : 0.9 to 1.5 atg (app)

Max. ambient temperature : 50⁰ 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 should be stainless steel and outlet flange is carbon steel.

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

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BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51834
		REV. 01
		PAGE 4 OF 8

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 m³/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 GD² 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.
- f) Bearing coefficients, loads and temperatures at 10, 50 and 100% load for all Gearbox bearings.
- g) Bearing geometry, clearances and pre-load for all Gearbox bearings.
- h) Report on bearing stability analysis

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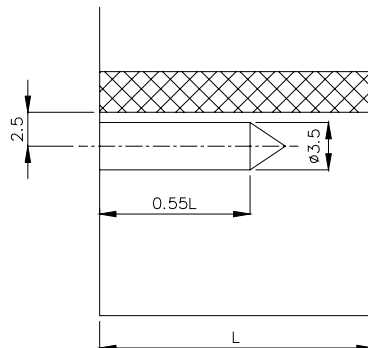
BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51834
		REV. 01
		PAGE 5 OF 8

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.
- i) 13 copies of operating and maintenance instructions for Gear box and Turning gear.
- j) 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.



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		REV. 01
		PAGE 6 OF 8
e) Turning gear with driving motor and necessary accessories like starting switch etc.. g) <u>Instrumentation :</u> 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. <u>PAINTING, PRESERVATION AND PACKING</u> 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.		
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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 (°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				
A C 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			
	SYNCH	36	SECONDARY VOLTAGE			
		37	SECONDARY OHMS			
		38	BREAKDOWN OR PULL OUT TORQUE %			
		39	RATED FIELD CURRENT			
D.C	40	RATED EXCITER VOLTAGE				
	41	RATED POWER FACTOR				
ALL FEATURES	42	PULL IN TORQUE % OF FULL LOAD				
	43	TYPE OF WINDING				
	44	SHUNT FIELD CURRENT				
	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					

BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51834
		REV. 01
		PAGE 8 OF 8

RECORD OF REVISIONS

REV NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	27/01/1998	NEW	C.N.V.R	C.N.V.R
01	11/07/2002	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, f, g & h) & 16(g) added g) Revision at point 17	G.R.RAO	C.N.V.R

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 HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS		TC 61560
			REV. 00
			PAGE 1 OF 5
<u>TECHNICAL SPECIFICATION FOR GEAR BOX WITH</u> <u>TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET</u>			
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.			
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 : $\pm 10\%$			
- Frequency : $\pm 5\%$			
- Combined Voltage & Frequency : $\pm 10\%$			
e) For general specification of gear box refer to TC 51835 Rev 02 . If any conflict between TC 51835 & TC 61560, TC 61560 is valid.			
f) Annexure to TC 61560 (6 sheets) shall be completely filled in by supplier duly signed 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 is to be fully automatic type i.e., engagement and disengagement should be automatic.			
j) Soft starter has to be supplied as a panel wired with timer, connectors etc.			
k) Optional price for Third party inspection has to be quoted.			
l) Radial (Journal) bearings for Pinion shaft should be Tilting pad type			
m) Each journal bearing should be provided with 2 nos of 3-wire Duplex RTDs			
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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 51834 & TC 61560)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gearbox output power	= 14200 kW.
Gear Service factor	= 1.4 minimum
Input speed	= 7150 RPM
Output speed	= 1500 RPM
Trip speed	= 7865 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

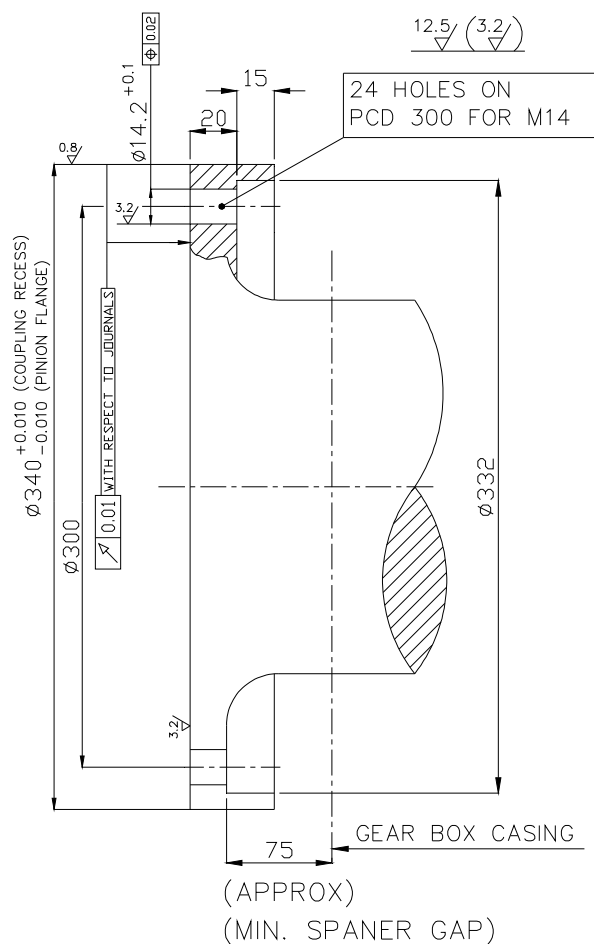
The Turning gear shall be designed to meet the following requirements:

Turning gear speed	= 100 RPM (approx.)
GD ² value of Turbine Rotor (Referred to turbine speed)	= 156 Kg-m ²
GD ² value of Generator Rotor (Referred to Generator speed)	= 2850 Kg-m ²
Break away torque of Turbine rotor	= 53 Kg-m ($\mu = 0.3$)
Break away torque of Generator rotor	= 421 Kg-m ($\mu = 0.3$)

5) 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 Flange Details



NOTE 1: The following coupling data may be considered for rotor dynamics of Pinion shaft:

Center of gravity location and half coupling weight on Pinion flange are 40 mm and 60 Kg respectively.

NOTE 2: 0.2% Yield strength of Pinion shaft material should be at least 550 N/mm²

FORMAT
TD-20
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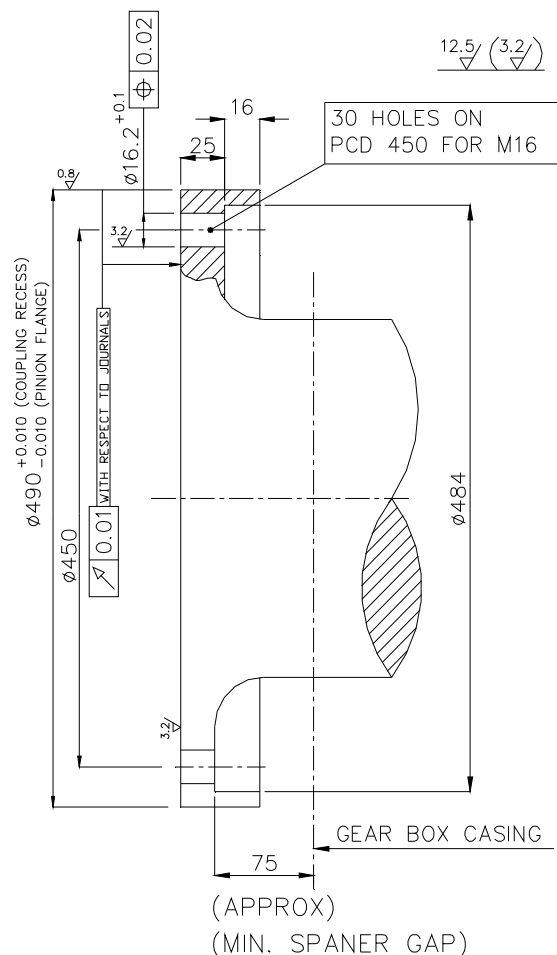
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6) Coupling between Gear box and Generator

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

Gear box locating key shall be under gear shaft so that no lateral movement of gear shaft takes place during operation.

GEAR SHAFT END DETAILS



NOTE 1) : Minimum tensile yield strength of gear shaft (flange) material must be 550 N/mm²

NOTE 2): The following coupling data may be considered for rotor dynamics of Gear shaft:

The center of gravity location and half coupling weight due to the Coupling between Gear box and Generator are 70 mm and 200 Kg respectively.

FORMAT
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00	23-05-2013	NEW	G.R.RAO	G.R.RAO



**PRODUCT STANDARD
TURBINES & COMPRESSORS**

TC 61556

REV. 00

PAGE 1 OF 5

**TECHNICAL SPECIFICATION OF GEAR BOX WITH
TURNING GEAR MOUNTED ON GEAR BOX FOR TG 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 at site condition should be within **85 dB(A)** at a distance of 1 meter.
- c) The gearbox shall be able to withstand 20% of overspeed for a period of minimum 5 minutes.
- d) Gearbox and Turning gear shall be designed considering the following Voltage and Frequency variations. The supplier should confirm the same.
 - Voltage : $\pm 10\%$
 - Frequency : $\pm 5\%$
 - Combined Voltage & Frequency : $\pm 10\%$
- e) For general specification of gear box refer to **TC 51835 Rev 02**. If any conflict between TC 51835 & TC 61556, TC 61556 is valid.
- f) Annexure to TC 61556 shall be filled in by supplier, duly signed 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 are to be automatic. **Soft starter has to be supplied as a panel wired with timer, transformer connectors etc.**
- j) **Type of Radial bearings for Low speed shaft should be Only Offset-half bearings.**

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PREPARED BY: G.R.RAO

APPROVED BY: CNVR

DATE : 05-01-2013

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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 Gearbox 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 61556)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gear box output power	= 41000 kW.
Gear Service factor	= 1.3 minimum
Input speed	= 5650 RPM
Output speed	= 3000 RPM
Trip speed	= 6215 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

NOTE : 0.2% Yield strength of Pinion and Gear shaft material should be at least 550 N/mm²

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)	= 1232 Kg-m ²
GD ² value of Generator Rotor (Referred to Generator speed)	= 5240 Kg-m ²
Break away torque of Turbine rotor	= 47 Kg-m ($\mu = 0.05$)
Break away torque of Generator rotor	= 126 Kg-m ($\mu = 0.05$)

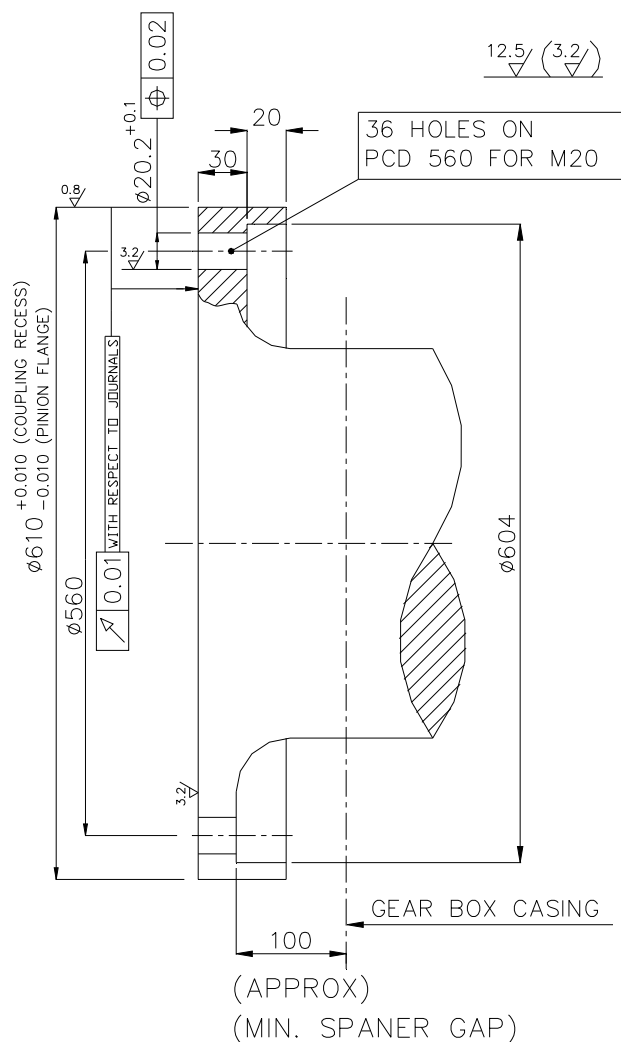
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5) Coupling between Gear box and Generator

The coupling is flexible membrane type, non-lubricated and with a spacer, and is in BHEL scope. 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.

GEAR SHAFT END DETAILS



NOTE : For rotor dynamics of gear box consider the following coupling values :

The center of gravity location and half coupling weight for Output Coupling are 70 mm and 250 Kg respectively.



**PRODUCT STANDARD
TURBINES & COMPRESSORS**

TC 61556

REV. 00

PAGE 5 OF 5

RECORD OF REVISIONS

REV. NO	DATE	REVISION DETAILS	REVISED	APPROVED
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FORMAT
TD-20
REV-00

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 HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS		TC 61554
			REV. 00
			PAGE 1 OF 5
<u>TECHNICAL SPECIFICATION OF GEAR BOX WITH</u> <u>TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET</u> 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 : $\pm 10\%$ - Frequency : $\pm 5\%$ - Combined Voltage & Frequency : $\pm 10\%$ e) For general specification of gear box refer to TC 51835 Rev 02. If any conflict between TC 51835 & TC 61554, TC 61554 is valid. f) Annexure to TC 61554 (6 sheets) shall be completely filled in by supplier duly signed and enclosed with offer. g) Reference list should be as per the enclosed 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 are to be automatic. Soft starter has to be supplied as a panel wired with timer, connectors etc. j) Each journal bearing should be provided with 2 nos of 3-wire Duplex RTDs.			
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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 61554)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gear box output power = 20000 kW.

Gear Service factor = 1.3 minimum

Input speed = 5300 RPM

Output speed = 1500 RPM

Trip speed = 5830 RPM.

Minimum yield strength of Turbine Rotor = 540 N/mm²

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.)

GD² value of Turbine Rotor (Referred to turbine speed) = 550 Kg-m²

GD² value of Generator Rotor (Referred to Generator speed) = 8673 Kg-m²

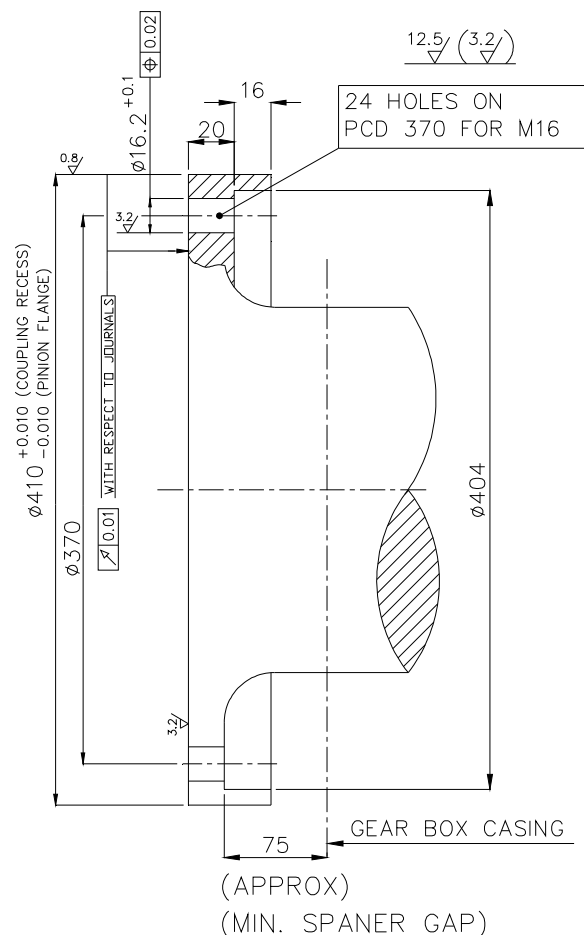
Break away torque of Turbine rotor = 28.2 Kg-m ($\mu = 0.05$, with jacking oil)

Break away torque of Generator rotor = 153 Kg-m ($\mu = 0.05$, with jacking oil)

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 65 Kg respectively. These values are tentative only. Final values shall be given after ordering the Gearbox.

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00	15-11-2012	NEW	G.R.RAO	G.R.RAO

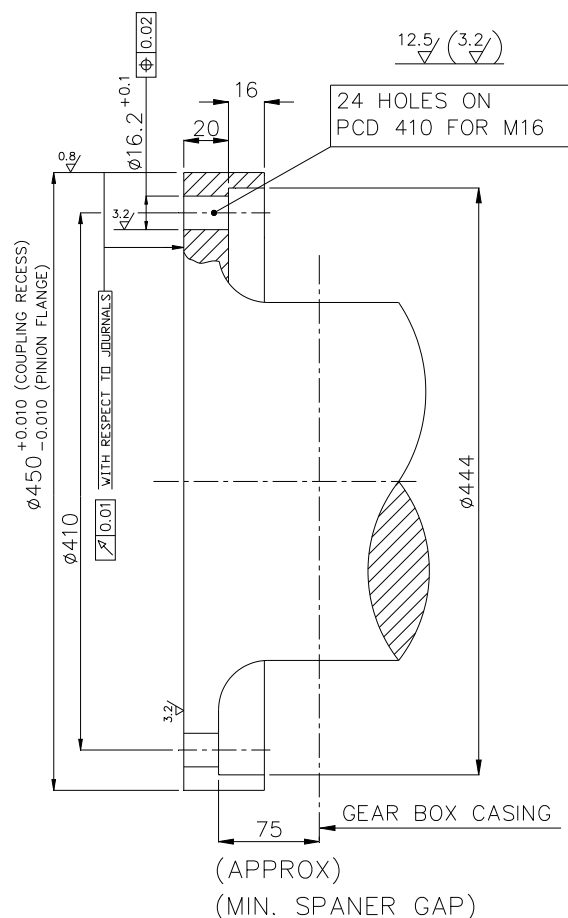
बीएचईएल  HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS		TC 61551
			REV. 00
			PAGE 1 OF 5
TECHNICAL SPECIFICATION OF GEAR BOX WITH TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET			
APPLICABLE STANDARD : AGMA 6011 - I 03			
PURPOSE : To function as a speed reducer between high speed steam turbine and 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 61551, TC 61551 is valid. f) Annexure to TC 61551 (6 sheets) shall be completely filled in by supplier duly signed and enclosed with offer. g) Reference list should be as per the enclosed 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 are to be automatic. Soft starter has to be supplied as a panel wired with timer, connectors etc. j) Each journal bearing should be provided with 2 nos of 3-wire Duplex RTDs.			
FORMAT TD-201 REV -00	PREPARED BY: G.R.RAO	APPROVED BY: G R RAO	DATE : 10-08-2012
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 HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 61551
		REV. 00
		PAGE 2 OF 5
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 61551) 3) DESIGN PARAMETERS The gear shall be designed to meet the following requirements: Gear box output power = 23700 kW. Gear Service factor = 1.3 minimum Input speed = 5000 RPM Output speed = 1500 RPM Trip speed = 5500 RPM. Minimum yield strength of Turbine Rotor = 540 N/mm² 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.) GD² value of Turbine Rotor (Referred to turbine speed) = 1220 Kg-m² GD² value of Generator Rotor (Referred to Generator speed) = 8643 Kg-m² Break away torque of Turbine rotor = 42 Kg-m (μ = 0.05) Break away torque of Generator rotor = 153 Kg-m (μ = 0.05)		
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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. These values are tentative only. Final values shall be given after ordering the Gearbox.

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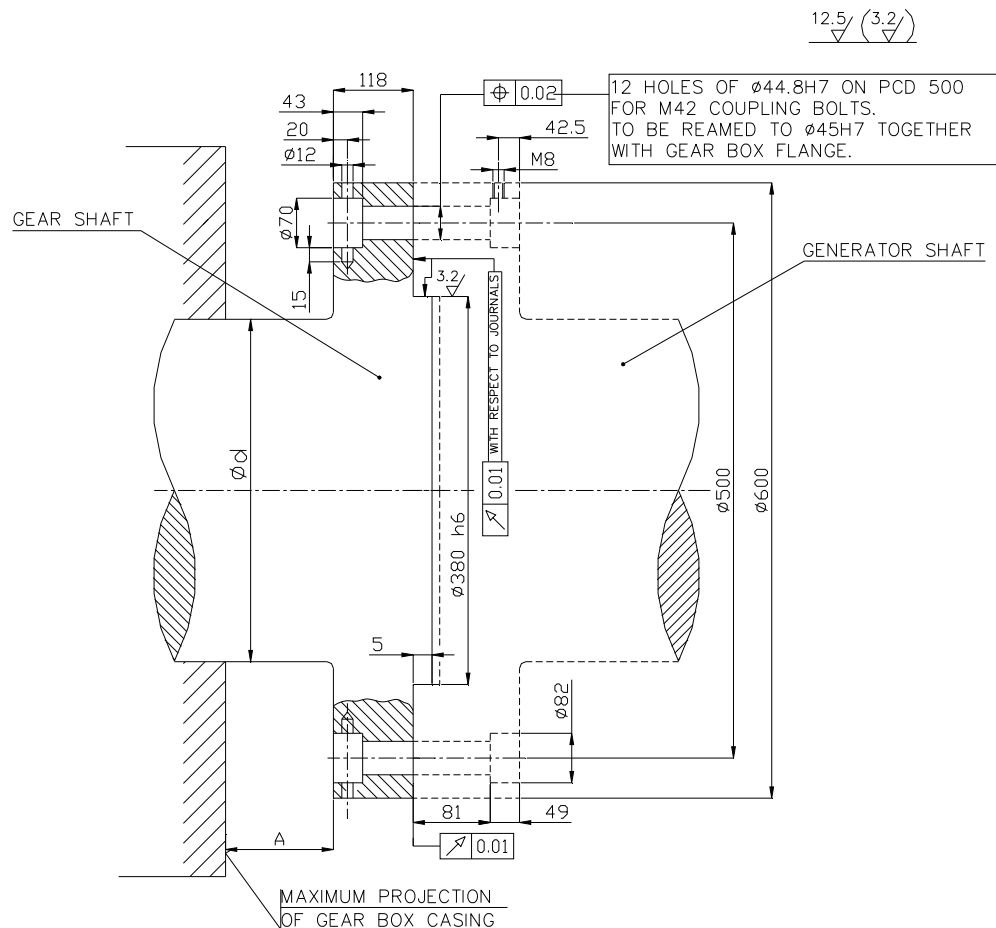
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5) Coupling between Gear box and Generator

This is a 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.

GEAR SHAFT FLANGE 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



**PRODUCT STANDARD
TURBINES & COMPRESSORS**

TC 61551

REV. 00

PAGE 5 OF 5

RECORD OF REVISIONS

REV.NO.	DATE	REVISION DETAILS	REVISED	APPROVED
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			REV. 00
			PAGE 1 OF 5
TECHNICAL SPECIFICATION FOR GEAR BOX WITH TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET			
APPLICABLE STANDARD : API 613 – 5th Edition			
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. 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 51834 Rev 01. If any conflict between TC 51834 & TC 61547, TC 61547 is valid. f) Annexure to TC 61547 (6 sheets) shall be completely filled in by supplier duly signed 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 is to be fully automatic type i.e., engagement and disengagement should be automatic. j) Soft starter has to be supplied as a panel wired with timer, connectors etc. k) Third party inspection if any, has to be as per the purchase enquiry. Optional price for Third party inspection has to be quoted.			
FORMAT TD-201 REV -00 REF DOC GAIL Pata 1x9 MW M/c No.T-1052	PREPARED BY: G.R.RAO	APPROVED BY: G.R.RAO	DATE : 30-03-2012
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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 51834 & TC 61547)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gearbox output power	= 9300 kW.
Gear Service factor	= 1.3 minimum
Input speed	= 8000 RPM
Output speed	= 1500 RPM
Trip speed	= 8800 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

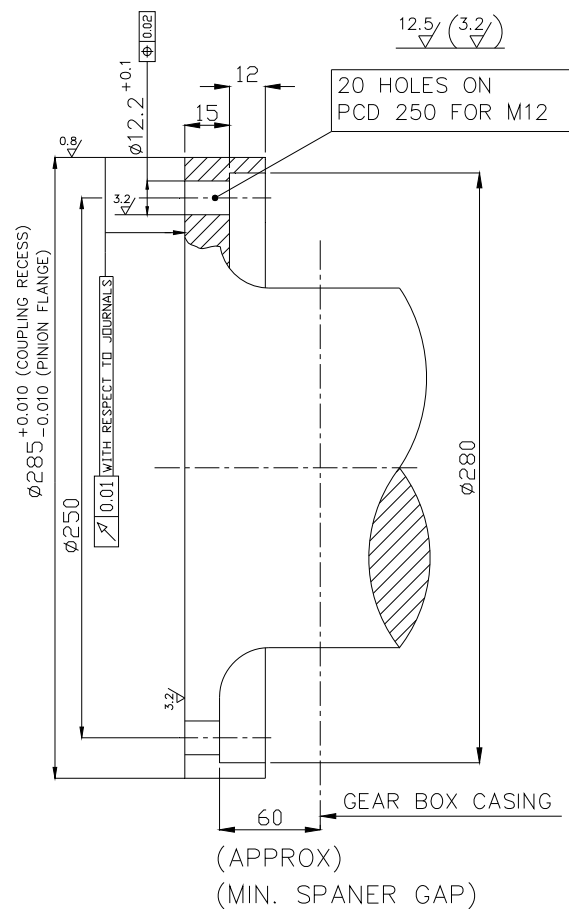
The Turning gear shall be designed to meet the following requirements:

Turning gear speed	= 100 RPM (approx.)
GD ² value of Turbine Rotor (Referred to turbine speed)	= 19 Kg-m ²
GD ² value of Generator Rotor (Referred to Generator speed)	= 3488 Kg-m ²
Break away torque of Turbine rotor	= 13 Kg-m ($\mu = 0.3$)
Break away torque of Generator rotor	= 440 Kg-m ($\mu = 0.3$)

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 Flange Details



NOTE 1: The flange design has to be verified by the vendor wrt short circuit torque (6 times of normal torque)

NOTE 2: The following coupling data may be considered for rotor dynamics of Pinion shaft:

Center of gravity location and half coupling weight on Pinion flange are 35 mm and 40 Kg respectively.

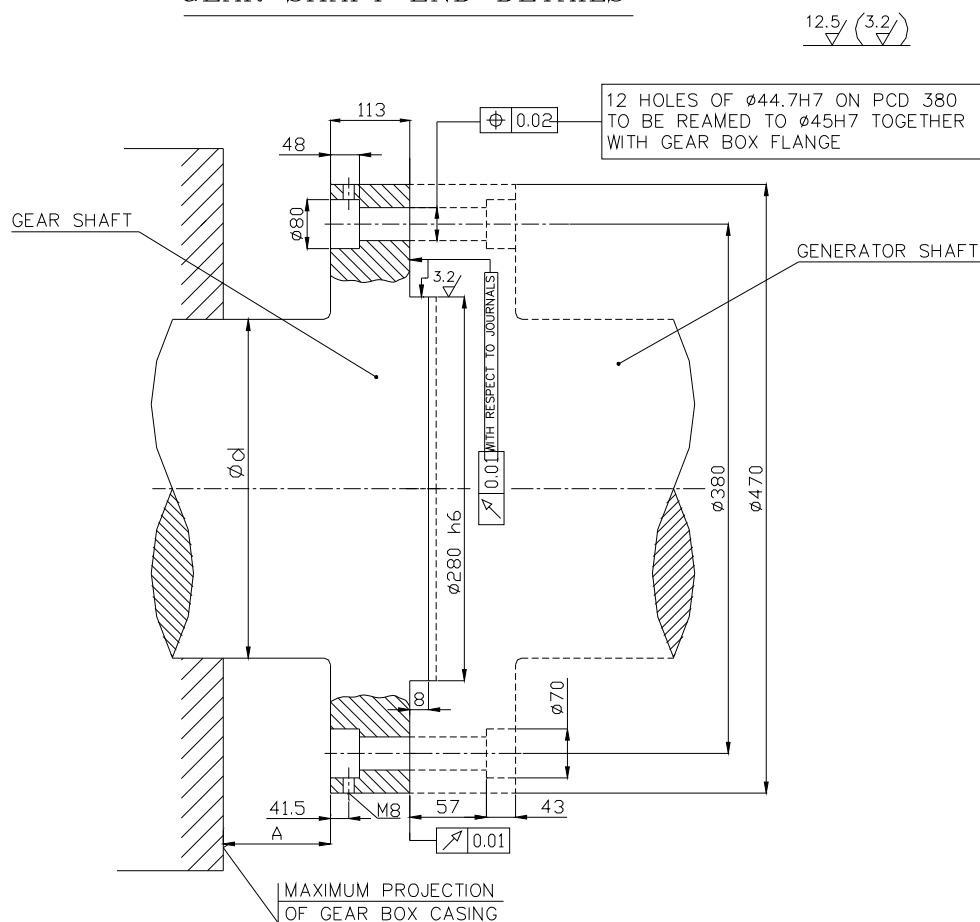
NOTE 3: **0.2% Yield strength of Pinion shaft material should be at least 550 N/mm²**

5) Coupling between Gear box and Generator

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

Gear box locating key shall be under gear shaft so that no lateral movement of gear shaft takes place during operation.

GEAR SHAFT END DETAILS



NOTE: IT IS PREFERABLE TO HAVE $A > 3d$

NOTE : 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	30-03-2012	NEW	G.R.RAO	G.R.RAO

**TECHNICAL SPECIFICATION FOR GEAR BOX WITH
TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET**

APPLICABLE STANDARD : **API 613 – 5th Edition**

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.
- 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 : $\pm 10\%$
 - Frequency : $\pm 5\%$
 - Combined Voltage & Frequency : $\pm 10\%$
- e) For general specification of gear box refer to **TC 51834 Rev 01**. If any conflict between TC 51834 & TC 61544, TC 61544 is valid.
- f) Annexure to TC 61544 (6 sheets) shall be completely filled in by supplier duly signed 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 is to be fully automatic type i.e., engagement and disengagement should be automatic.**
- j) **Soft starter has to be supplied as a panel wired with timer, connectors etc.**
- k) **Optional price for Third party inspection has to be quoted.**

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PREPARED BY: G.R.RAO

APPROVED BY: G.R.RAO

DATE : 22-03-2012

REF DOC

GAIL Pata 2x25 MW
M/c Nos.T-1053 & 1054

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

- 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.
- Preliminary gear box drawing, foundation details and torsional analysis data (Preliminary geometry of pinion and Gear shafts).
- Confirmation that pinion damped critical speeds are above 120% of operating speeds under no load to full load condition.
- Confirmation to any of the requirements of the specifications (TC 51834 & TC 61544)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gearbox output power	= 25700 kW.
Gear Service factor	= 1.3 minimum
Input speed	= 5000 RPM
Output speed	= 3000 RPM
Trip speed	= 5500 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)	= 2000 Kg-m ²
GD ² value of Generator Rotor (Referred to Generator speed)	= 2800 Kg-m ²
Break away torque of Turbine rotor	= 62 Kg-m ($\mu = 0.05$)
Break away torque of Generator rotor	= 70 Kg-m ($\mu = 0.05$)

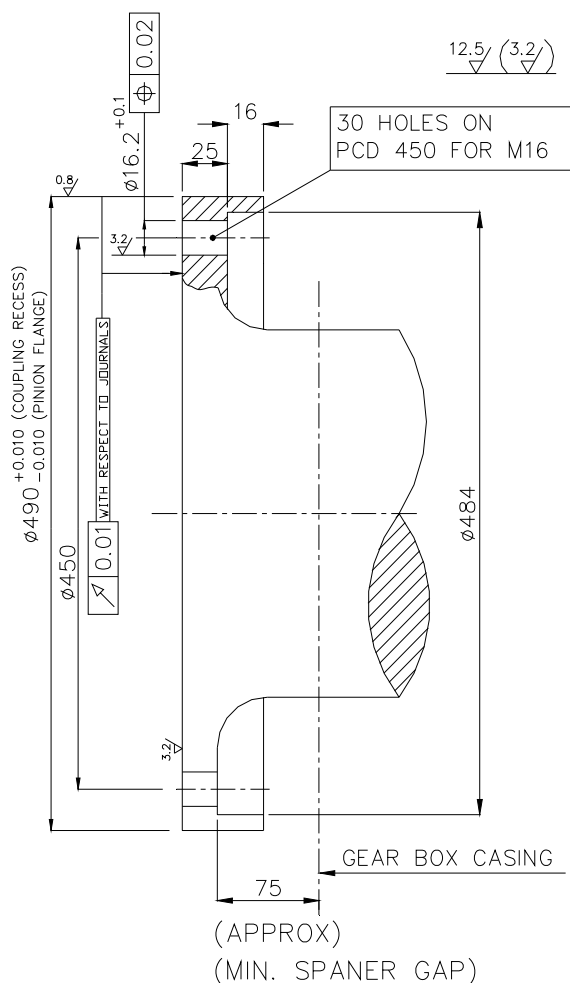
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6) Coupling between Gear box and Generator

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

Gear box locating key shall be under gear shaft so that no lateral movement of gear shaft takes place during operation.

GEAR SHAFT END DETAILS



NOTE 1) : **Minimum tensile yield strength of gear shaft (flange) material must be 550 N/mm²**

NOTE 2): The following coupling data may be considered for rotor dynamics of Gear shaft:

The center of gravity location and half coupling weight due to the Coupling between Gear box and Generator are 70 mm and 200 Kg respectively.

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REV. NO	DATE	REVISION DETAILS	REVISED	APPROVED
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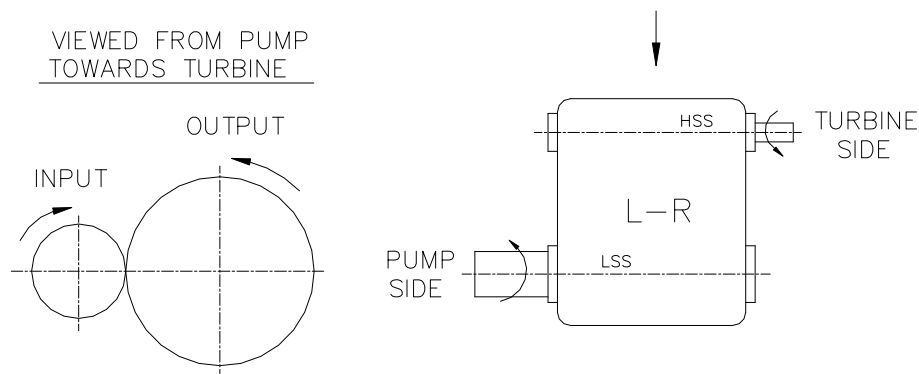
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PAGE 1 OF 7

**TECHNICAL SPECIFICATION FOR GEAR BOX
AND COUPLING BETWEEN GEAR BOX & TURBINE**

Applicable Standards: **AGMA 6011-I03**

1. **PURPOSE** : To function as a speed reducer between high speed Steam Turbine and low speed Booster pump.
2. **TYPE OF GEAR BOX** : Parallel shafts, double helical gears with horizontal offset of shafts
3. **Operating Parameters:**
 - a) **Gear box output Power (kW)** : **1200**
 - b) **Gear box input Speed (RPM)** : **4950**
 - c) **Gear box output Speed (RPM)** : **1495**
 - d) **Turbine trip Speed (RPM)** : **5445**
4. a) Direction of rotation of input shaft as viewed from Pump towards Turbine: **Clockwise**
b) Direction of rotation of output shaft as viewed from Turbine towards Pump: **Clockwise**.
c) **Service factor shall not be less than 2.0**
d) The layout of gear and pinion shafts shall be as shown below.



GEAR BOX LAYOUT

5. a) Tooth of gear wheel and pinion : Hardened and ground
b) Peripheral Speed : <150m/sec
c) Low speed gear shall be of forged steel , securely keyed to the shaft and High speed pinion shall be of heat treated forged steel with integral shaft.

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**PREPARED BY:
G.R.RAO.**

**APPROVED BY:
D S RAO**

**DATE:
04-11-2011**

**REF DOC
T-0981-984**

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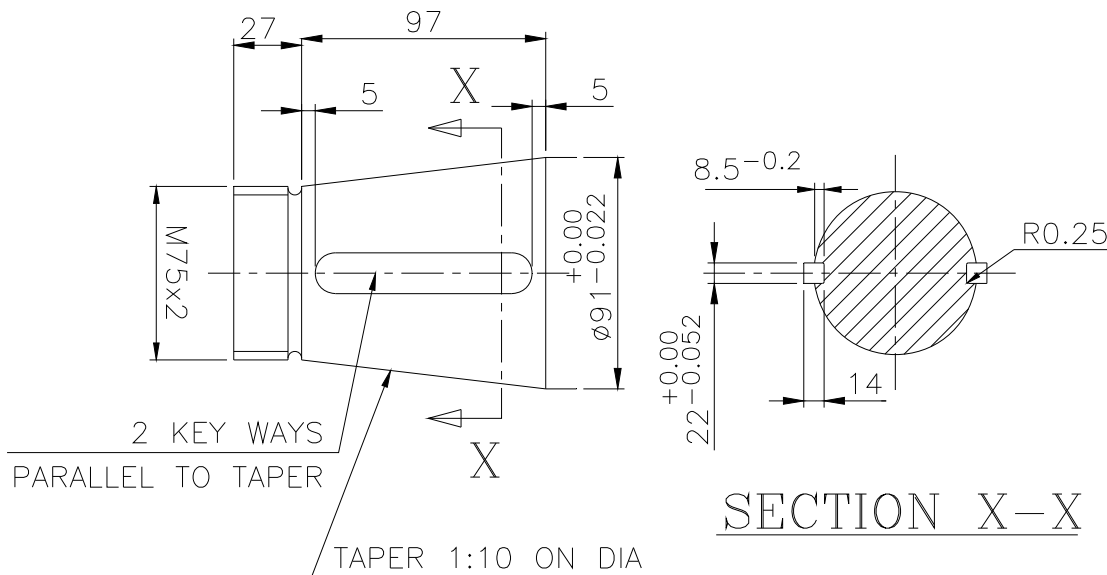
REV. 00

PAGE 2 OF 7

6. a) Gear box casing shall be horizontally split.
b) A minimum sump depth of 300 mm below the bottom of the gear shall be provided.
7. a) **Coupling between turbine and gear box:** The coupling shall be flexible gear type, tip-centered, filled type and with a spacer. The coupling has to take the movement of rotor end (+6 mm approximately) due to thermal expansion. Turbine has a thrust bearing.
b) The coupling shall be selected suitable for the turbine shaft end shown below.
Total coupling length = 582.45 mm
Taper in coupling bore = 1:10
Shrinkage = 0.6 per thou.
Two keyways 180 ° apart as per DIN 6885, sheet 2 shall be provided.

TURBINE ROTOR END DETAILS

(Input Coupling hub to be mounted on the Turbine rotor shall be made to suit these details)



- c) The shaft end detail for the output coupling is as per the sketch given below.
Half coupling weight acting on the output shaft has to be simulated during MRT

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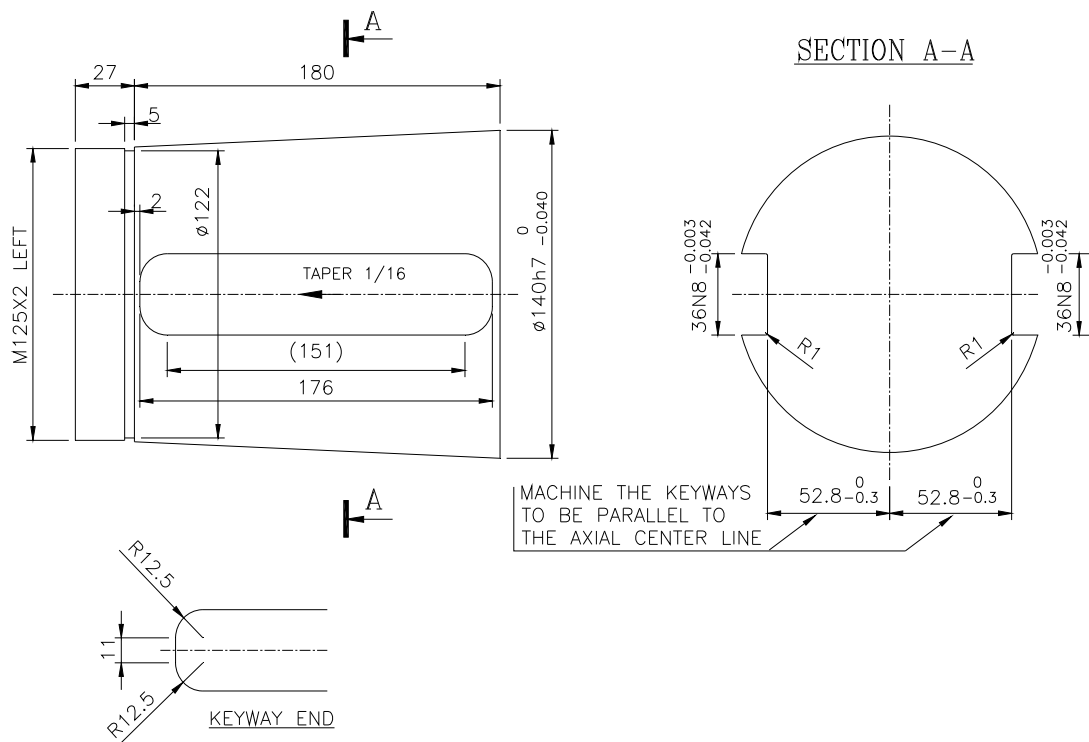
TC 61527

REV. 00

PAGE 3 OF 7

of the Gearbox. The output coupling drawing or details of half coupling weight shall be furnished after ordering the Gear box. The simulated weight is to be balanced to Q0.67.

Gear box Low speed shaft end details



Shrinkage = 0.6 per Thousand

8. NOISE LEVEL : Maximum permissible Noise Level should be within 85 dB(A) at a distance of 1m.
9. VIBRATIONS :
 - a) Shaft vibrations should be within limits specified by **API 613**
 - b) Casing vibrations should be within 7 mm/sec.
10. INSPECTION AND TESTS :
 - a) Inspection and testing is according to **API 613**.
 - b) Material tests and reports for all gear box components as per relevant international standards.
 - c) **US and MPI testing of forgings.**

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TURBINES & COMPRESSORS**

TC 61527

REV. 00

PAGE 4 OF 7

- d) Leak testing of housing.
 - e) Tooth roughness measurement.
 - f) Backlash measurement for gear mesh.
 - g) Vibration and noise measurement.
 - h) Full speed no load test shall be conducted according to **API 613**.
11. Lube oil connections (oil inlet and drain) shall be provided on the left side of the gearbox (when viewed from driving machine to driven machine). Surfaces coming in contact with oil should not be painted and to be cleaned and to be preserved properly. The temperature rise of oil should not be more than 15° to 20° with inlet oil temperature being 40° to 50° C.
- | | |
|--------------------------|------------------------|
| Lube oil to be used | : ISO VG46 Grade |
| Pressure of oil | : 0.9 to 1.5 ata (app) |
| Max. ambient temperature | : 50° C |
| Environment | : Humid and tropic |
12. Data to be supplied along with the offer :
- a) Dimensional drawings of gear box and couplings
 - 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 m³/hr.
 - e) Heat dissipation in Kcal/hr.
 - f) Materials used for different parts of gear box (gear wheel ,pinion, casing, coupling etc.,)
 - g) Weight of gear wheel and pinion shafts, size of bearings, pitch circle diameter of couplings.
 - h) Reference list of similar gear boxes and couplings supplied earlier.
 - i) Item wise price is to be given for the following :
 - i) Gear Box
 - ii) Input Coupling
 - iii) One set of internals
 - iv) Spares for two years operation
 - j) Quality Plan
 - k) Filled in API data sheets
 - l) Deviations to AGMA-6011
 - m) Efficiency of Gear box at 25, 50, 75 and 100% loads.
13. Data to be supplied after placement of order within 15 days:
- a) Final filled in data sheets of gear box and coupling in API formats.
 - b) Final torsional analysis data of gear box and couplings like GD² values, spring Constants and geometry for pinion and gear wheel shafts, GD² values and spring constants of individual components (i.e., of hubs and sleeves) for couplings to calculate the torsional critical speeds of the system.

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TC 61527

REV. 00

PAGE 5 OF 7

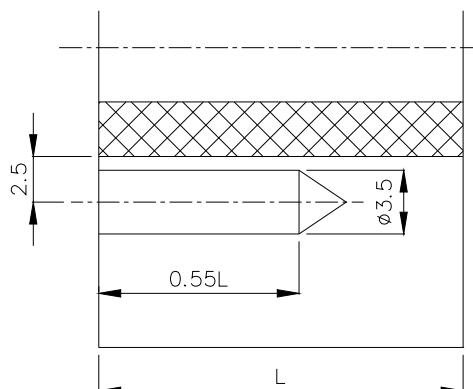
- c) Specific tooth load
- d) Specific pressure on the journal bearings and thrust bearings.
- e) Stress at the base of teeth.
- f) Gear geometry of pinion and wheel (no. of teeth, module, helix angle etc.)
- g) Speed Vs Torque characteristics curve for gear box.
- h) Dimensional drawings.

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

- a) Mounting lengths for vibration probes.
- b) Alignment values for gear box and operating instruction.
- c) Wiring diagram for thermoelements provided at gear box bearings.
- d) Three hard copies and one floppy copy of final (Approved) Gear box and coupling drawings.
- e) 30 copies of operating instructions for gear box and drawing.

15 SCOPE OF SUPPLY :

- a) Gear box with thermometers (one per bearing for measuring the bearing oil temperature). Gear box input and output shafts are to be fixed with all mounting and to be dynamically balanced to a quality of Q2.5 of VDI 2060. Provision shall be made for vibration pick-ups of Bentley Nevada make (Two radial probes per each journal bearing and one axial probe for thrust bearings). All connections should be NPT $\frac{3}{4}$ " and holes are to be plugged and shaft portion to be polished.
Provision shall be made in the journal bearings for pencil type RTD's as shown below.



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TURBINES & COMPRESSORS**

TC 61527

REV. 00

PAGE 6 OF 7

- b) Coupling between Turbine and gear box.
- c) 6no. of 3-wire duplex Pt100 RTD's calibrated according to DIN 43760 shall be provided (one per journal bearing and one on each side of thrust bearings). They shall be wired to a common junction box mounted on the gear box. Junction box shall be in supplier's scope. A wiring diagram for the RTD's shall be supplied.
- d) Spare parts for two years operation.

16 Additional requirements.

- a). The gear unit shall be specifically designed for continuous service at the speed required for the application. Precision and accuracy of manufacture is essential in order to minimize the problems of vibration, impact stresses, noise distortion and lubrication.
- b). Double helical gears cut by hobbing process, or approved equal, and dynamically balanced shall be used. Bidders shall submit detailed specifications of the materials used including factor of safety etc.
- c). Oversized bearings shall be designed to operate at low unit pressures when transmitting the required horse power. Bearings shall be of the split sleeve type with a high grade centrifugally cast tin-base babbit lining. Bearings shall be accurately machined to ensure perfect alignment. Gear journal bearings shall have babbitted thrust faces next to the gear to act as locating surfaces for the gear train.
- d). The 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 and stress relieved before machining. The faces of adjoining sections shall be accurately machined to provide oil tight joints. The housing shall be generously proportioned and of rigid construction to provide permanent alignment of rotating parts and protection from possible external vibration. The arrangement shall be such that it will be possible to lift gear case cover without disturbing the alignment of shaft, gear and pinion.
- e). The gearing and bearings shall be pressure lubricated with oil supplied from the central lubrication system of the respective pump sets.

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TC 61527

REV. 00

PAGE 7 OF 7

RECORD OF REVISIONS

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PRODUCT STANDARD TURBINES & COMPRESSORS

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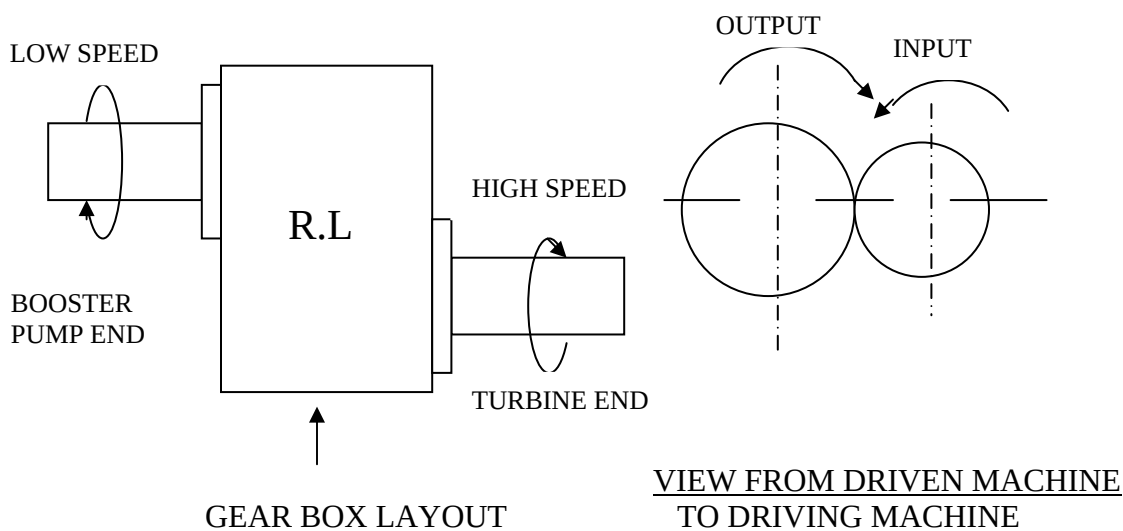
PAGE 1 OF 7

TECHNICAL SPECIFICATION FOR GEAR BOX AND GEAR COUPLING FOR BFP DRIVE TURBINE

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

1. PURPOSE : To function as a speed reducer between high speed Steam Turbine and low speed Booster pump.
2. TYPE OF GEAR BOX : Parallel shafts, double helical gears with horizontal offset of shafts
3.

	Design Condition	Best Efficiency Point	Runout Condition	Emergency Condition
a) Gear box output Power (kW)	640	533	615	630
b) Gear box input Speed (RPM)	5550	5350	5635	5715
c) Gear box output Speed (RPM)	1495	1441	1518	1539
d) Turbine trip Speed (RPM)	6105	6105	6105	6105
4. a) Direction of rotation of input shaft as viewed from driven machine: Anti Clockwise
 b) Direction of rotation of output shaft as viewed from driving machine towards driven machine: Counter Clockwise.
 c) **Service factor shall not be less than 2.0**
 d) The layout of gear and pinion shafts shall be as shown below.



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PREPARED BY:
G.R.RAO.

APPROVED BY:
C.N.V. RAMANA

DATE:
13-01-2010

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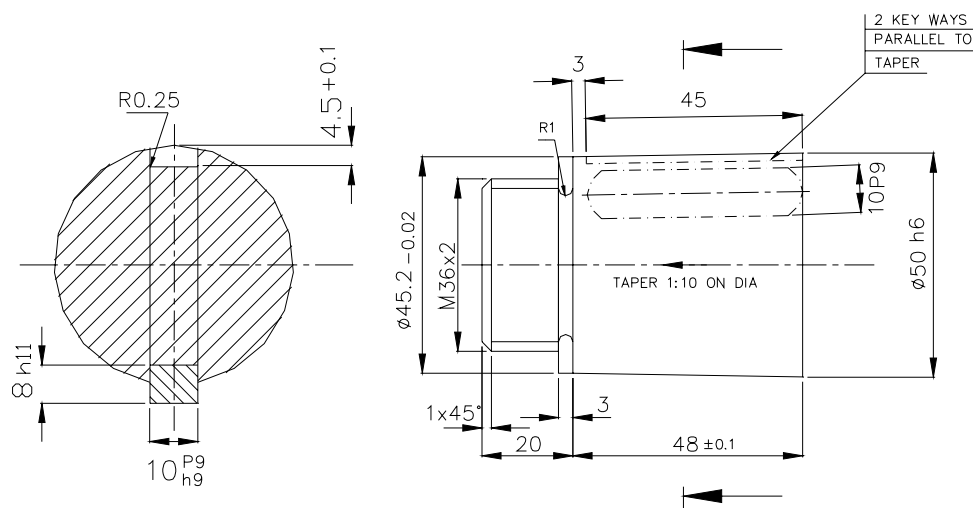
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PAGE 2 OF 7

5. a) Tooth of gear wheel and pinion : Hardened and ground
b) Peripheral Speed : <150m/sec
c) Low speed gear shall be of forged steel , securely keyed to the shaft and High speed pinion shall be of heat treated forged steel with integral shaft.
6. a) Gear box casing shall be horizontally split.
b) A minimum sump depth of 300 mm below the bottom of the gear shall be provided.
7. a) Coupling between turbine and gear box .The coupling shall be flexible gear type, tip-centered, filled type and with a spacer. This has to take the movement of rotor end (+6 mm approximately) due to thermal expansion. Turbine has a thrust bearing.
b) The input coupling shall be selected suitable for the turbine shaft end shown below.
Taper in coupling bore = 1:10
Shrinkage = 0.6 per thou.
Two keyways 180 ° apart as per DIN 6885, sheet 2 shall be provided.

TURBINE ROTOR END DETAILS AT THE INPUT COUPLING

(Input coupling hub, to be mounted on turbine rotor shall be made to suit these details)



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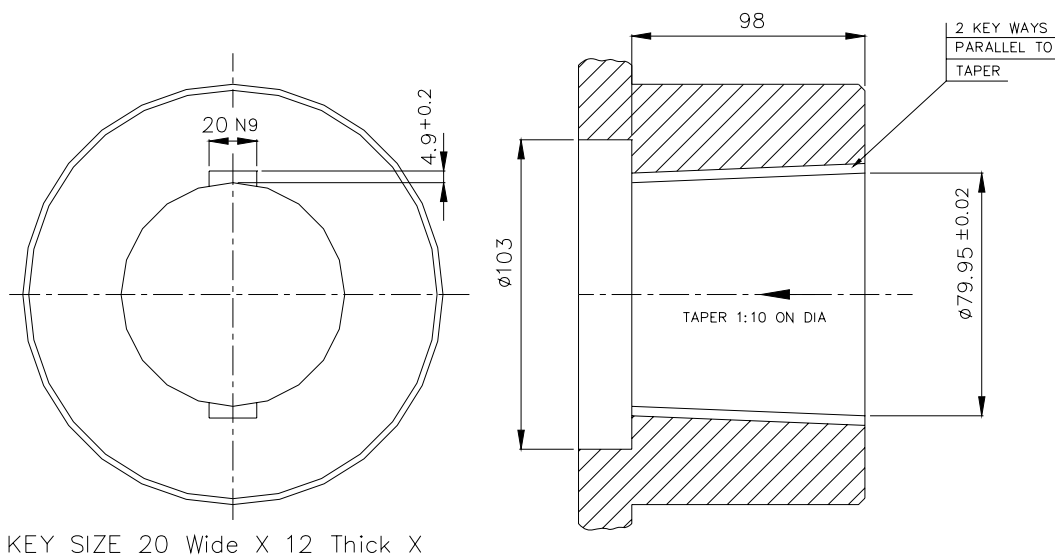
REV 00

PAGE 3 OF 7

- c) The shaft end detail for the output coupling is as per the sketch given below. Half coupling weight acting on the output shaft has to be simulated during MRT of the Gearbox. The simulated weight is to be balanced to Q0.67.

DETAILS OF OUTPUT COUPLING HUB, TO BE MOUNTED ON GEAR BOX OUTPUT SHAFT.

(Gear box output shaft shall be made to suit these details)



KEY SIZE 20 Wide X 12 Thick X

SHRINKAGE = 0.6 per Thousand

(Output coupling drawing will be supplied to gear box supplier by BHEL after placing the order.)

8. NOICE LEVEL : Maximum permissible Noise Level should be within 85 dB(A) at a distance of 1m.
9. VIBRATIONS :
- a) Shaft vibrations should be within limits specified by **API 613**
 - b) Casing vibrations should be within 7 mm/sec.
10. INSPECTION AND TESTS :
- a) Inspection and testing is according to **API 613**.
 - b) Material tests and reports for all gear box components as per relevant international standards.
 - c) US and MPI testing of forgings.

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PAGE 4 OF 7

- d) Leak testing of housing.
 - e) Tooth roughness measurement.
 - f) Backlash measurement for gear mesh.
 - g) Vibration and noise measurement.
 - h) Full speed no load test shall be conducted according to **API 613**.
11. Lube oil connections (oil inlet and drain) shall be provided on the left side of the gearbox (when viewed from driving machine to driven machine). Surfaces coming in contact with oil should not be painted and to be cleaned and to be preserved properly. The temperature rise of oil should not be more than 15° to 20° with inlet oil temperature being 40° to 50° C.
- Lube oil to be used : ISO VG46 Grade
Pressure of oil : 0.9 to 1.5 ata (app)
Max. ambient temperature : 50° C
Environment : Humid and tropic
12. Data to be supplied along with the offer :
- a) Dimensional drawings of gear box and couplings
 - 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 m³/hr.
 - e) Heat dissipation in Kcal/hr.
 - f) Materials used for different parts of gear box (gear wheel ,pinion, casing, coupling etc.,)
 - g) Weight of gear wheel and pinion shafts, size of bearings, pitch circle diameter of couplings.
 - h) Reference list of similar gear boxes and couplings supplied earlier.
 - i) Item wise price is to be given for the following :
 - i) Gear Box
 - ii) Input Coupling
 - iii) One set of internals
 - iv) Spares for two years operation
 - j) Quality Plan
 - k) Filled in API data sheets
 - l) Deviations to AGMA-6011
 - m) Efficiency of Gear box at Best Efficiency Point (B.E.P) to be supplied.
13. Data to be supplied after placement of order within 15 days:
- a) Final filled in data sheets of gear box and coupling in API formats.
 - b) Final torsional analysis data of gear box and couplings like GD² values, spring Constants and geometry for pinion and gear wheel shafts, GD² values and spring constants of individual components (i.e., of hubs and sleeves) for couplings to calculate the torsional critical speeds of the system.

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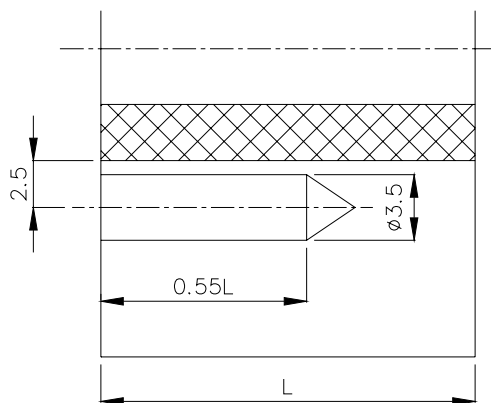
- c) Specific tooth load
- d) Specific pressure on the journal bearings and thrust bearings.
- e) Stress at the base of teeth.
- f) Gear geometry of pinion and wheel (no. of teeth, module, helix angle etc.)
- g) Speed Vs Torque characteristics curve for gear box.
- h) Dimensional drawings.

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

- a) Mounting lengths for vibration probes.
- b) Alignment values for gear box and operating instruction.
- c) Wiring diagram for thermoelements provided at gear box bearings.
- d) Three hard copies and one floppy copy of final (Approved) Gear box and coupling drawings.
- e) 30 copies of operating instructions for gear box and drawing.

15 SCOPE OF SUPPLY :

- a) Gear box with thermometers (one per bearing for measuring the bearing oil temperature). Gear box input and output shafts are to be fixed with all mounting and to be dynamically balanced to a quality of Q2.5 of VDI 2060. Provision shall be made for vibration pick-ups of Bentley Nevada make (Two radial probes per each journal bearing and one axial probe for thrust bearings). All connections should be NPT $\frac{3}{4}$ " and holes are to be plugged and shaft portion to be polished.
Provision shall be made in the journal bearings for pencil type RTD's as shown below.



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PAGE 6 OF 7

- b) Coupling between Turbine and gear box.
- c) 6no. of 3-wire duplex Pt100 RTD's calibrated according to DIN 43760 shall be provided (one per journal bearing and one on each side of thrust bearings). They shall be wired to a common junction box mounted on the gear box. Junction box shall be in supplier's scope. A wiring diagram for the RTD's shall be supplied.
- d) Spare parts for two years operation.

16 Additional requirements.

- a). The gear unit shall be specifically designed for continuous service at the speed required for the application. Precision and accuracy of manufacture is essential in order to minimize the problems of vibration, impact stresses, noise distortion and lubrication.
- b). Double helical gears cut by hobbing process, or approved equal, and dynamically balanced shall be used. Bidders shall submit detailed specifications of the materials used including factor of safety etc.
- c). Oversized bearings shall be designed to operate at low unit pressures when transmitting the required horse power. Bearings shall be of the split sleeve type, bronze/steel backed with a high grade centrifugally cast tin-base babbitt lining. Bearings shall be accurately machined to ensure perfect alignment. Gear journal bearings shall have babbitted thrust faces next to the gear to act as locating surfaces for the gear train.
- d). The 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 and stress relieved before machining. The faces of adjoining sections shall be accurately machined to provide oil tight joints. Two oil level gauges, drain, fill vent and thermometer dipstick shall be furnished for the gear casing. The housing shall be generously proportioned and of rigid construction to provide permanent alignment of rotating parts and protection from possible external vibration. The arrangement shall be such that it will be possible to lift gear case cover without disturbing the alignment of shaft, gear and pinion.
- e). The gearing and bearings shall be pressure lubricated with oil supplied from the central lubrication system of the respective pump sets.

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PAGE 7 OF 7

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REV NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	13-01-2010	New	G.R.RAO	C.N.V.R

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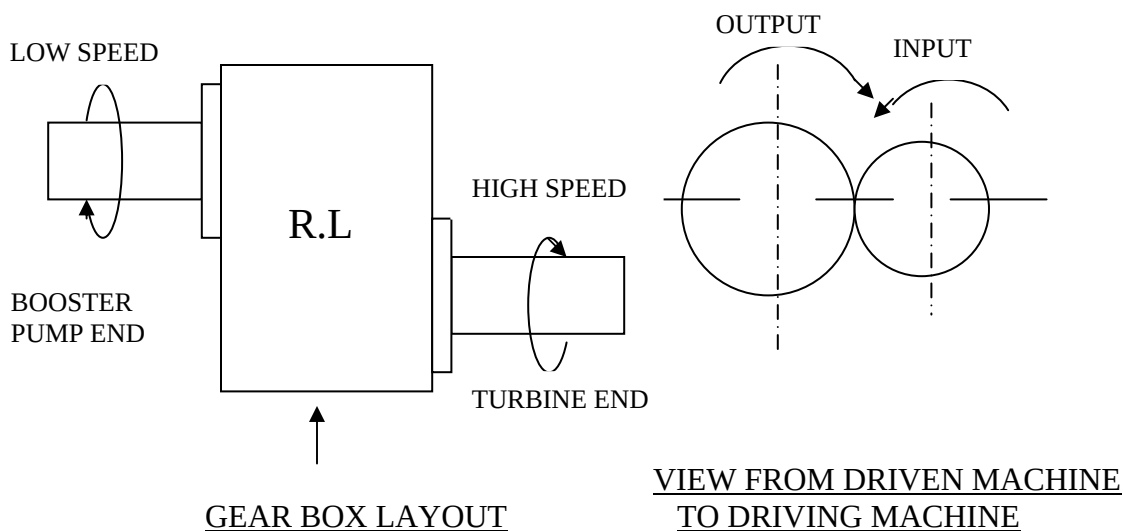
PAGE 1 OF 7

TECHNICAL SPECIFICATION FOR GEAR BOX AND GEAR COUPLING FOR BFP DRIVE TURBINE

Applicable Standards: **AGMA 6011-I03**

1. PURPOSE : To function as a speed reducer between high speed Steam Turbine and low speed Booster pump.
2. TYPE OF GEAR BOX : Parallel shafts, double helical gears with horizontal offset of shafts
3. Operating Parameters:

a) Gear box output Power (kW)	:	775
b) Gear box input Speed (RPM)	:	5710
c) Gear box output Speed (RPM)	:	1495
d) Turbine trip Speed (RPM)	:	6281
4. a) Direction of rotation of input shaft as viewed from driven machine: Anti Clockwise
 b) Direction of rotation of output shaft as viewed from driving machine towards driven machine: Anti Clockwise.
 c) **Service factor shall not be less than 2.0**
 d) The layout of gear and pinion shafts shall be as shown below.



5. a) Tooth of gear wheel and pinion : Hardened and ground
 b) Peripheral Speed : <150m/sec
 c) Low speed gear shall be of forged steel , securely keyed to the shaft and High speed pinion shall be of heat treated forged steel with integral shaft.

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PREPARED BY:
G.R.RAO.

APPROVED BY:
C.N.V. RAMANA

DATE:
06-12-2010

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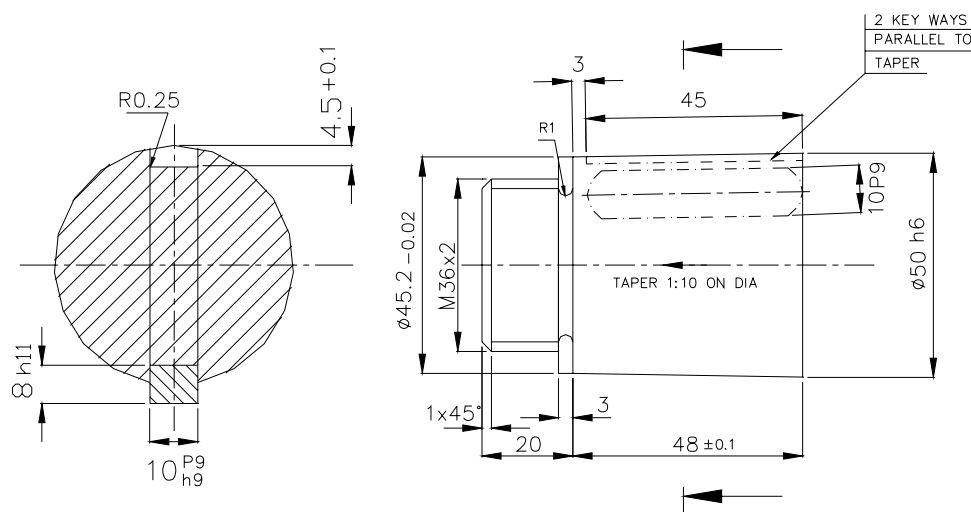
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PAGE 2 OF 7

6. a) Gear box casing shall be horizontally split.
b) A minimum sump depth of 300 mm below the bottom of the gear shall be provided.
7. a) Coupling between turbine and gear box .The coupling shall be flexible gear type, tip-centered, filled type and with a spacer. This has to take the movement of rotor end (+6 mm approximately) due to thermal expansion. Turbine has a thrust bearing.
b) The input coupling shall be selected suitable for the turbine shaft end shown below.
Taper in coupling bore = 1:10
Shrinkage = 0.6 per thou.
Two keyways 180 ° apart as per DIN 6885, sheet 2 shall be provided.

TURBINE ROTOR END DETAILS AT THE INPUT COUPLING

(Input coupling hub, to be mounted on turbine rotor shall be made to suit these details)



SHRINKAGE = 0.6 per Thousand

- c) The shaft end detail for the output coupling is as per the sketch given below. Half coupling weight acting on the output shaft has to be simulated during MRT of the Gearbox. The simulated weight is to be balanced to Q0.67.

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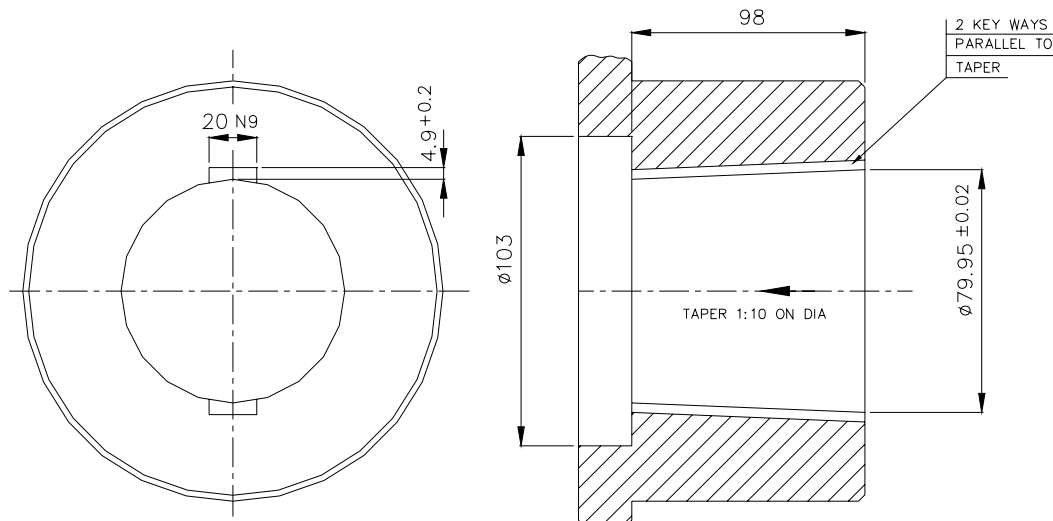
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PAGE 3 OF 7

DETAILS OF OUTPUT COUPLING HUB, TO BE MOUNTED ON GEAR BOX OUTPUT SHAFT.

(Gear box output shaft shall be made to suit these details)



KEY SIZE 20 Wide X 12 Thick X

SHRINKAGE = 0.6 per Thousand

(Output coupling drawing will be supplied to gear box supplier by BHEL after placing the order.)

8. **NOISE LEVEL** : Maximum permissible Noise Level should be within 85 dB(A) at a distance of 1m.
9. **VIBRATIONS** :
 - a) Shaft vibrations should be within limits specified by **API 613**
 - b) Casing vibrations should be within 7 mm/sec.
10. **INSPECTION AND TESTS** :
 - a) Inspection and testing is according to **API 613**.
 - b) Material tests and reports for all gear box components as per relevant international standards.
 - c) **US and MPI testing of forgings.**
 - d) Leak testing of housing.
 - e) Tooth roughness measurement.
 - f) Backlash measurement for gear mesh.

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REV 00

PAGE 4 OF 7

- g) Vibration and noise measurement.
h) Full speed no load test shall be conducted according to **API 613**.
11. Lube oil connections (oil inlet and drain) shall be provided on the left side of the gearbox (when viewed from driving machine to driven machine). Surfaces coming in contact with oil should not be painted and to be cleaned and to be preserved properly. The temperature rise of oil should not be more than 15° to 20° with inlet oil temperature being 40 to 50° C.
- Lube oil to be used : ISO VG46 Grade
Pressure of oil : 0.9 to 1.5 ata (app)
Maximum ambient temperature : 50° C
Environment : Humid and tropic
12. Data to be supplied along with the offer :
- a) Dimensional drawings of gear box and couplings
 - 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 m³/hr.
 - e) Heat dissipation in Kcal/hr.
 - f) Materials used for different parts of gear box (gear wheel ,pinion, casing, coupling etc.,)
 - g) Weight of gear wheel and pinion shafts, size of bearings, pitch circle diameter of couplings.
 - h) Reference list of similar gear boxes and couplings supplied earlier.
 - i) Item wise price is to be given for the following :
 - i) Gear Box
 - ii) Input Coupling
 - iii) One set of internals
 - iv) Coupling Hub (Turbine side)
 - v) Spares for two years operation
 - j) Quality Plan
 - k) Filled in API data sheets
 - l) Deviations to AGMA-6011
13. Data to be supplied after placement of order within 15 days:
- a) Final filled in data sheets of gear box and coupling in API formats.
 - b) Final torsional analysis data of gear box and couplings like GD² values, spring Constants and geometry for pinion and gear wheel shafts, GD² values and spring constants of individual components (i.e., of hubs and sleeves) for couplings to calculate the torsional critical speeds of the system.
 - c) Specific tooth load
 - d) Specific pressure on the journal bearings and thrust bearings.
 - e) Stress at the base of teeth.

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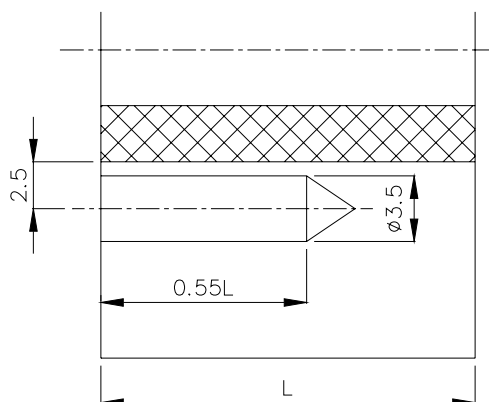
- f) Gear geometry of pinion and wheel (no. of teeth, module, helix angle etc.)
- g) Speed Vs Torque characteristics curve for gear box.
- h) Dimensional drawings.

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

- a) Mounting lengths for vibration probes.
- b) Alignment values for gear box and operating instruction.
- c) Wiring diagram for thermoelements provided at gear box bearings.
- d) Three hard copies and one floppy copy of final (Approved) Gear box and coupling drawings.
- e) 30 copies of operating instructions for gear box and Gear coupling.

15. SCOPE OF SUPPLY :

- a) Gear box with thermometers (one per bearing for measuring the bearing oil temperature). Gear box input and output shafts are to be dynamically balanced to a quality of Q2.5 of VDI 2060. Provision shall be made for vibration pick-ups of Bentley Nevada make (Two radial probes per each journal bearing and one axial probe for thrust bearings). All connections should be NPT 3/4" and holes are to be plugged and shaft portion to be polished.
- b) Provision shall be made in the journal bearings for pencil type RTD's as shown below. 6no.of 3-wire duplex Pt100 RTD's calibrated according to DIN 43760 shall be provided (one per journal bearing and one on each side of thrust bearings). They shall be wired to a common junction box mounted on the gear box. Junction box shall be in supplier's scope. A wiring diagram for the RTD's shall be supplied.



- c) Coupling between Turbine and gear box.

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PAGE 6 OF 7

16 Additional requirements.

- a). The gear unit shall be specifically designed for continuous service at the speed required for the application. Precision and accuracy of manufacture is essential in order to minimize the problems of vibration, impact stresses, noise distortion and lubrication.
- b). Double helical gears cut by hobbing process, or approved equal, and dynamically balanced shall be used. Bidders shall submit detailed specifications of the materials used including factor of safety etc.
- c). Oversized bearings shall be designed to operate at low unit pressures when transmitting the required horse power. Bearings shall be of the split sleeve type with a high grade centrifugally cast tin-base babbit lining. Bearings shall be accurately machined to ensure perfect alignment. Gear journal bearings shall have babitted thrust faces next to the gear to act as locating surfaces for the gear train.
- d). The 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 and stress relieved before machining. The faces of adjoining sections shall be accurately machined to provide oil tight joints. The housing shall be generously proportioned and of rigid construction to provide permanent alignment of rotating parts and protection from possible external vibration. The arrangement shall be such that it will be possible to lift gear case cover without disturbing the alignment of shaft, gear and pinion.
- e). The gearing and bearings shall be pressure lubricated with oil supplied from the central lubrication system of the respective pump sets.

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00	06-12-2010	New	G.R.RAO	C.N.V.R

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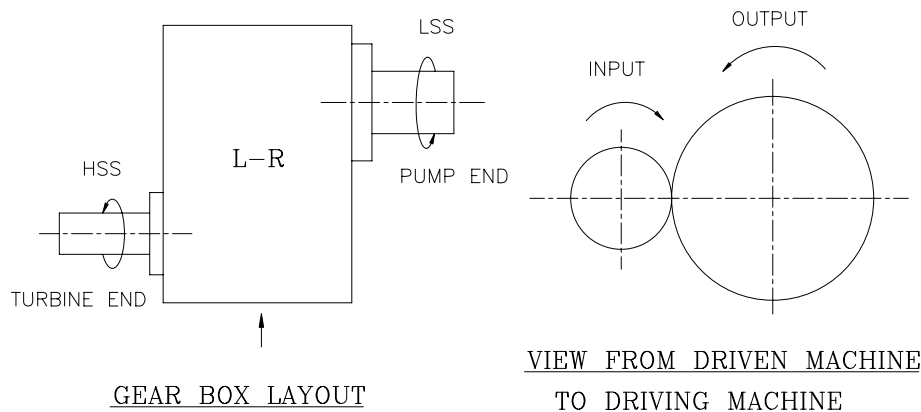
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TECHNICAL SPECIFICATION FOR GEAR BOX BETWEEN STEAM TURBINE AND BOILER FEED PUMP

Applicable Standards: **API 613 – 5th Edition**

1. PURPOSE : To function as a speed reducer between high speed Steam Turbine and low speed Boiler Feed Pump (BFP).
2. TYPE OF GEAR BOX : Parallel shafts, double helical gears with horizontal offset of shafts
3. Design Parameters:

Gearbox Output Power	: 2150 kW
Gearbox Input Speed	: 9000 RPM
Gearbox Output Speed	: 2980 RPM
Turbine Trip Speed	: 9900 RPM
4. a) Direction of rotation of input shaft as viewed from **driving** machine: Anti Clockwise
 b) Direction of rotation of output shaft as viewed from **driven** machine: Anti Clockwise.
 c) **Service factor shall not be less than 2.0**
 d) The layout of gear and pinion shafts shall be as shown below.



5. a) Tooth of gear wheel and pinion : Hardened and ground
 b) Peripheral Speed : <150m/sec
 c) Low speed gear shall be of forged steel , securely keyed to the shaft and High speed pinion shall be of heat treated forged steel with integral shaft.
 d) Gear box casing shall be horizontally split.

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PREPARED BY:
G.R.RAO.

APPROVED BY:
C.NV.RAMANA

DATE:
30-12-2008

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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:

[illegible]

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

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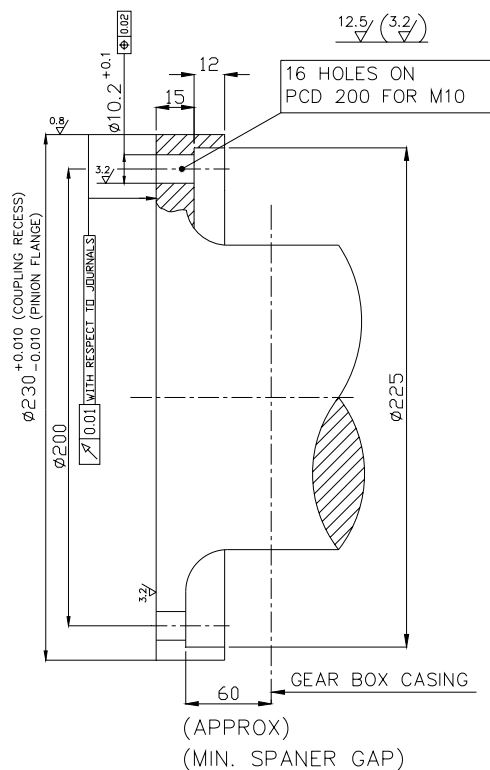
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REV. 01

PAGE 3 OF 7

GEAR SHAFT END DETAILS



Half coupling weight acting on the Input and output shafts are to be simulated during MRT of the Gearbox. The simulated weight is to be balanced to Q0.67. The Coupling drawings shall be furnished to the Gearbox supplier after placing the Gearbox order.

8. NOISE LEVEL : Maximum permissible Noise Level should be within 85 dB(A) at a distance of 1m.
9. VIBRATIONS :
 - a) Shaft vibrations should be within limits specified by API 613
 - b) Casing vibrations should be within limits specified by VDI2056.
10. INSPECTION AND TESTS :
 - a) Inspection and testing is according to API 613.

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- b) Material tests and reports for all gear box components as per relevant international standards.
- c) US and MPI testing of forgings.
- d) Leak testing of housing.
- e) Tooth roughness measurement.
- f) Backlash measurement for gear mesh.
- g) Vibration and noise measurement.
- h) Full speed no load test shall be conducted according to API 613.
11. Lube oil connections (oil inlet and drain) shall be provided on the left side of the gearbox (when viewed from driving machine to driven machine). Surfaces coming in contact with oil should not be painted and to be cleaned and to be preserved properly. The temperature rise of oil should not be more than 15° to 20° with inlet oil temperature being 40° to 50° C.
- Lube oil to be used : ISO VG46 Grade
- Pressure of oil : 0.9 to 1.5 ata (app)
- Max. ambient temperature : 50° C
- Environment : Humid and tropic
12. Data to be supplied along with the offer :
- a) Dimensional 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.
- e) Heat dissipation in Kcal/hr.
- 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 supplied earlier.
- i) Item wise price is to be given for the following :
- i) Gear Box
- ii) Set of Gear internals
- iii) Set of Bearings for HSS
- iv) Set of Bearings for LSS
- v) Set of Oil Seals
- j) Quality Plan
- k) Filled in API data sheets
- l) Deviations to API 613 – 5th Edition
13. Data to be supplied after placement of order within 15 days:
- a) Final filled in data sheets of gearbox in API formats.
- b) Final torsional analysis data of gearbox like GD^2 values, spring Constants and geometry for pinion and gear wheel shafts,

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PAGE 5 OF 7

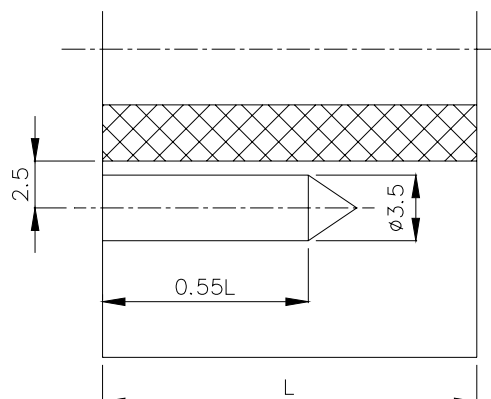
- c) Specific tooth load
- d) Specific pressure on the journal bearings and thrust bearings.
- e) Stress at the base of teeth.
- f) Gear geometry of pinion and wheel (no. of teeth, module, helix angle etc.)
- g) Speed Vs Torque characteristics curve for gear box.
- h) Dimensional drawings.

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

- a) Mounting lengths for vibration probes.
- b) Alignment values for gear box and operating instruction.
- c) Wiring diagram for thermoelements provided at gear box bearings.
- d) Three hard copies and one floppy copy of final (Approved) Gear box drawing.
- e) 13 copies of operating instructions for gear box.

15 SCOPE OF SUPPLY :

- a) Gear box with thermometers (one per bearing for measuring the bearing oil temperature). Gear box input and output shafts are to be fixed with all mountings and to be dynamically balanced to a quality of Q2.5 of VDI 2060. Provision shall be made for vibration pick-ups of Bentley Nevada make (Two radial probes per each journal bearing and one axial probe for thrust bearings). All connections should be NPT $\frac{3}{4}$ " and holes are to be plugged and shaft portion to be polished.
Provision shall be made in the journal bearings for pencil type RTD's as shown below.



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**PRODUCT STANDARD
TURBINES & COMPRESSORS**

TC61469

REV. 01

PAGE 6 OF 7

- b) 3-wire duplex Pt100 RTD's calibrated according to DIN 43760 shall be provided (one per journal bearing and one on each side of thrust bearings). They shall be wired to a common junction box mounted on the gear box. Junction box shall be in supplier's scope. A wiring diagram for the RTD's shall be supplied.

16 Additional requirements.

- a). The gear unit shall be specifically designed for continuous service at the speed required for the application. Precision and accuracy of manufacture is essential in order to minimize the problems of vibration, impact stresses, noise distortion and lubrication.
- b). Double helical gears cut by hobbing process, or approved equal, and dynamically balanced shall be used. Bidders shall submit detailed specifications of the materials used including factor of safety etc.
- c). Oversized bearings shall be designed to operate at low unit pressures when transmitting the required horse power. Bearings shall be of the split sleeve type, steel backed with a high grade centrifugally cast tin-base babbitt lining. Bearings shall be accurately machined to ensure perfect alignment.
- d). The 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 and stress relieved before machining. The faces of adjoining sections shall be accurately machined to provide oil tight joints. The housing shall be generously proportioned and of rigid construction to provide permanent alignment of rotating parts and protection from possible external vibration. The arrangement shall be such that it will be possible to lift gear case cover without disturbing the alignment of shaft, gear and pinion.
- e). The gearing and bearings shall be pressure lubricated with oil supplied from the central lubrication system of the respective pump sets.

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**PRODUCT STANDARD
TURBINES & COMPRESSORS**

TC61469

REV. 01

PAGE 7 OF 7

RECORD OF REVISIONS

REV NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	30-12-2008	NEW	G.R.RAO	C.N.V.R
01	29-01-2010	Gearbox Output Power increased from 1900 to 2150 kW for MRPL BFPDT (T-0890 & 891)	G.R.RAO	C.N.V.R

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TC61455

REV. 00

PAGE 1 OF 6

**TECHNICAL SPECIFICATION OF GEAR BOX WITH
TURNING GEAR MOUNTED ON GEAR BOX FOR TG SET**

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

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

The Supplier should submit the offer with following options:

Option 1 : Gearbox with Turning gear & Centrifugal Pump mounted

Option 2 : Gearbox with Turning gear only.

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 : $\pm 10\%$
 - Frequency : $\pm 5\%$
 - Combined Voltage & Frequency : $\pm 10\%$
- e) For general specification of gear box refer to TC 51835 **Rev 02**. If any conflict between TC 51835 & TC61455, TC61455 is valid.
- f) Annexure to TC61455 (6 sheets) shall be completely filled in by supplier duly signed and enclosed with offer.
Reference list should be as per the enclosed format.
- g) Gearbox footprint details given in preliminary drawing are to be final and not to be changed after ordering..
- h) **Turning gear shall be fully automatic type** i.e. engagement and disengagement are to be automatic.

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TD-201
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PREPARED BY: G.R.RAO

APPROVED BY: CNVR

DATE : **23-08-2008**

REF DOC
M/C Nos.:
T-0832 & 833

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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 & TC61455)

3) DESIGN PARAMETERS

The gear shall be designed to meet the following requirements:

Gear box output power = 30800 kW.

Gear Service factor = 1.3 minimum

Input speed = 5650 RPM

Output speed = 1500 RPM

Trip speed = 6215 RPM.

Minimum yield strength of Turbine Rotor = 540 N/mm²

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.)

GD² value of Turbine Rotor (Referred to turbine speed) = 680 Kg-m²

GD² value of Generator Rotor (Referred to Generator speed) = 12652 Kg-m²

Break away torque of Turbine rotor = 23 Kg-m ($\mu = 0.05$)

Break away torque of Generator rotor = 198 Kg-m ($\mu = 0.05$)

The Main oil pump shall be designed to meet the following requirements:

Type of pump: Gear box output shaft driven **Centrifugal pump**, mounted on the gear box.

Discharge pressure = 9 bar g

Additional oil quantity to be handled by the pump over and above
the oil requirement of the gear box = 1275 LPM

(Total pump capacity = 1275 LPM + Gear box lube oil requirement)

Pump suction and discharge flanges shall be ANSI flanges.

Suction Lift (Height from minimum oil level in oil tank to the Pump center line) : 3.2 m

Total length of horizontal pipe in suction line : 16 m

No. of 90° bends in suction line : 5

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

- e) 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.
- f) Preliminary gear box drawing, foundation details and torsional analysis data (Preliminary geometry of pinion and Gear shafts).
- g) Confirmation that pinion damped critical speeds are above 120% of operating speeds under no load to full load condition.
- h) Confirmation to any of the requirements of the specifications (TC 51835 & TC 61455)
- i) Filled in data sheets for Main oil pump
- j) Performance curves for Main oil pump
- k) Pump GA drawing and its orientation with reference to Gear box

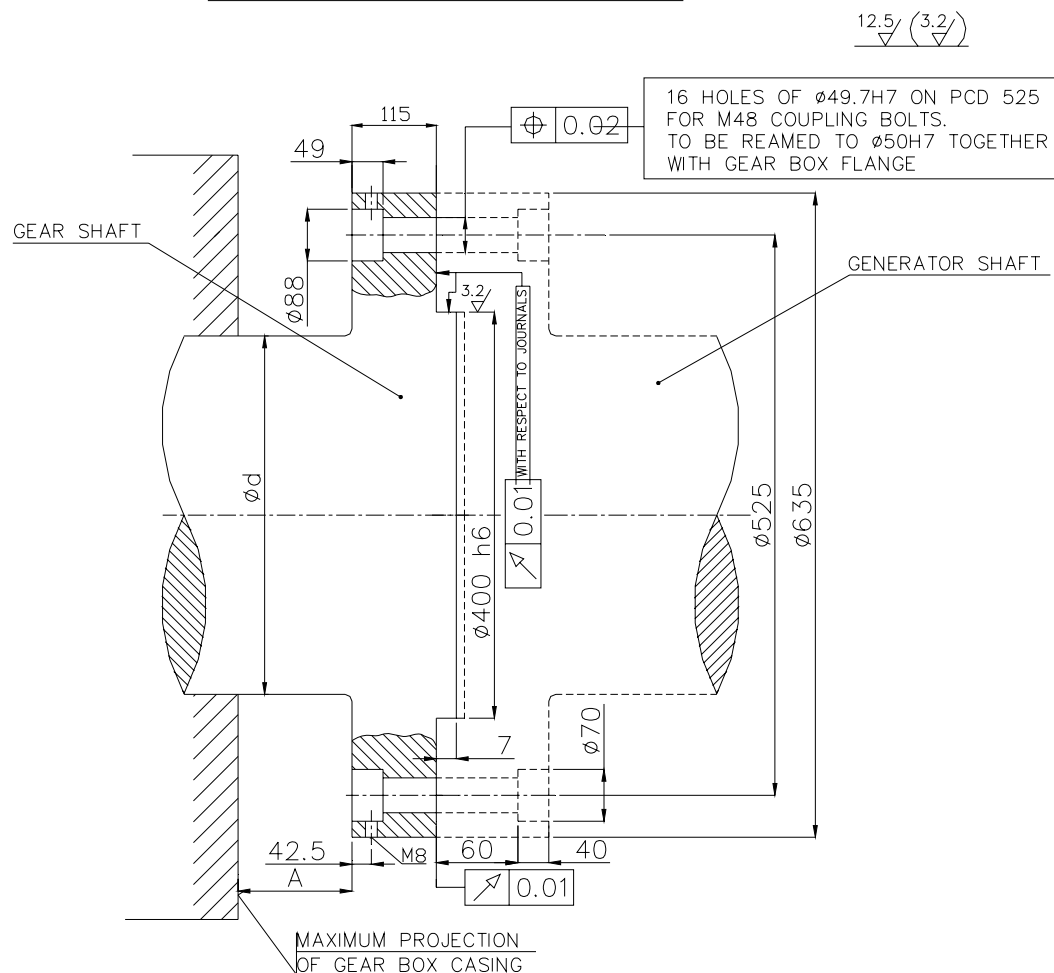
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5) Coupling between Gear box and Generator

This is a 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.

GEAR 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

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TD-20
REV-00

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**PRODUCT STANDARD
TURBINES & COMPRESSORS**

TC61455

REV. 00

PAGE 6 OF 6

RECORD OF REVISIONS

REV.NO.	DATE	REVISION DETAILS	REVISED	APPROVED
00	23-08-2008	NEW	G.R.RAO	C.N.V.R

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TD-20
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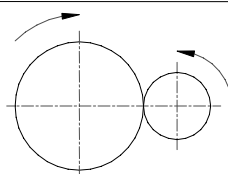
BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51835
		REV. 02
		PAGE 1 OF 8

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

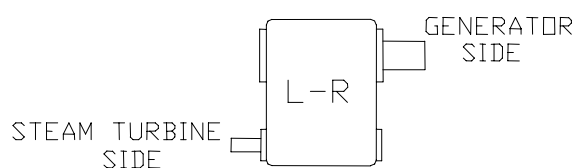
Applicable standards : **AGMA 6011-I 03**

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.

VIEWS FROM
STEAM TURBINE
TOWARDS GENERATOR



TOP VIEW



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.

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		REV. 02
		PAGE 2 OF 8

8. NOISE LEVEL :

Maximum permissible noise level is given in job specification.

9. VIBRATIONS :

- Shaft vibrations should be within limits specified by AGMA.
- 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.

FORMAT
TD-202
REV-00

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BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51835
		REV. 02
		PAGE 3 OF 8
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 20⁰ C with inlet oil temperature being 40⁰ C to 50⁰ C. Pressure of oil : 0.9 to 1.5 atg (app) Max. ambient temperature : 50⁰ 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.		
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		REV. 02
		PAGE 4 OF 8

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 m³/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 GD² 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.

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BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51835
		REV. 02
		PAGE 5 OF 8

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.

The diagram is a cross-sectional view of a journal bearing. It shows a central shaft (dashed line) within a bearing housing. The bearing housing is represented by a cross-hatched area. A vertical dimension line on the left indicates a distance of 2.5 from the top of the bearing to the centerline of the shaft. A horizontal dimension line below the shaft indicates a distance of 0.55L from the left end of the bearing to the centerline of the shaft. A vertical dimension line on the right indicates a distance of 3.5 from the centerline of the shaft to the outer edge of the bearing. The total length of the bearing is labeled as L.

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

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		REV. 02
		PAGE 6 OF 8

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.

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MOTOR DATA SHEET						
A L L M O T O R S	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 (°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				
A C M O T O R S	S Q C A G E	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			
	S Y C H	36	SECONDARY VOLTAGE			
		37	SECONDARY OHMS			
		38	BREAKDOWN OR PULL OUT TORQUE %			
		39	RATED FIELD CURRENT			
D.C	40	RATED EXCITER VOLTAGE				
	41	RATED POWER FACTOR				
A L L F E A T U R E S	42	PULL IN TORQUE % OF FULL LOAD				
	43	TYPE OF WINDING				
	44	SHUNT FIELD CURRENT				
	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					

BHEL HYDERABAD	PRODUCT STANDARD TURBINES & COMPRESSORS	TC 51835
		REV. 02
		PAGE 8 OF 8

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

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