SECTION - C

TECHNICAL SPECIFICATIONS OF STORES AND DRAWINGS.

Technical Specifications for 42GHz/500kW/500ms Gyrotron Tube which includes supply, installation and commissioning of Gyrotron Tube on the cryomagnet of existing 42GHz ECRH system at IPR and test for full parameters

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Technical Specifications for 42GHz Gyrotron Tube

(Supply, installation and commissioning of 42GHz Gyrotron Tube on existing ECRH system)

The scope of indent for new 42GHz/500kW/500ms Gyrotron tube includes supply, installation and commissioning of Gyrotron tube on the cryomagnet of existing 42GHz ECRH system at IPR and test for full parameters. This include the replacement of the existing Gyrotron tube and install the new tube.

Available infrastructure at IPR

The Gyrotron tube should be compatible to the existing 42 GHz Gyrotron set-up at IPR. This Gyrotron will be installed on the Cryomagnet, the technical details for the Gyrotron system are as follows:

a) Cryomagnet
Diameter of Cryomagnet:
Nature of magnet: liquid helium cooled cryomagnet
Height of magnet: 400mm
Height including the feedthrough: 805mm
Bore diameter of Gyrotron: 160mm
Maximum load to Cryomagnet: Less than 180kg (Gyrotron weight)
No. of magnets in the Gyrotron magnet system: 01
Magnet profile of magnet: Information not available

b) Water Cooling system:
The Gyrotron will be operational with full power 500kW for 500ms with the existing water-cooling system at IPR (total flow: ~500 lpm @ 4.0 bar maximum)

c) Power supply system:
The Gyrotron will be operated with the existing power supplies at IPR (Main High voltage 50kV-20A (negative) and 30-100mA(positive). The Filament power supply 30V-20A and the cryomagnet power supply 100A.

d) Output connection detail:
The output of Gyrotron will be connected to a matching optic unit suitable to design for mode purity 95%, The input of matching optic unit is opening of 150mm diameter.

e) Space availability for the Gyrotron installation:
The Gyrotron system is already installed on a cryo-magnet and it is operational. The new Gyrotron tube would replace the old tube. However, in case of fresh installation, a space of 1.5m x 1.5m is available and it should match the transmission line at height of 1.8m.

Note: If the vendor can't offer the Gyrotron compatible to the existing magnetic system and matching optic unit of IPR, the vendor is allowed to quote for Gyrotron along with their own magnet and matching optic unit system. In case of matching unit supplied by the vendor, it should be matched with the 63.5mm ID corrugated waveguide based transmission line. The vendor is requested to quote the Gyrotron including the cost of magnet and matching optic unit.

The detailed Technical Specifications for the Gyrotron tube are as follows:

1. Frequency of operation	: **42 GHz**
2. Stability of frequency during operation	: within ± 0.10 GHz
3. Drift of frequency with temperature rise	: within - 0.10 GHz
4. Output power (variable from 10% to 100%)	**: Maximum 500 kW**
5. Pulse width	**: 500ms**
6. Maximum temperature of the gyrotron	: Specify for 500kW/500ms

Type of Gyrotron: Depressed Collector

7. Output mode of the gyrotron	: **HE_{11}** with internal mode converter
8. Modulation mode	: 10 ms to 100ms
9. Harmonic content	: < 5% of maximum output power
10. Efficiency	: 45 % or better
11. Power in other modes	: less than 5% of output power
12. Output compatibility	: suitable to connect with existing MOU
13. Mode purity	: ≥ 95% after MOU
14. Critical crater energy	: ~ 10 J (Specify the maximum safe value)
15. Life time	: maximum of 5000 filament hours at full power
16. Shelf Life	: 5 yrs of shelf life.

Warranty: For Two years from the date of successful acceptance tests performed at IPR for performance of all the components the Gyrotron. In case of failure due to material defect/fabrication/design fault, complete replacement (within time frame to be mutually agreed upon).

17. V.S.W.R.	: max. 1.2
18. Nature of output	: lateral
19. Weight of the Gyrotron	: acceptable weight to be installed safely on the Cryomagnet
20. Physical dimension of the gyrotron	: Diameter of Gyrotron suitable to installed on the existing Cryomagnet at IPR
21. Storage requirements	:Vendors packing at room temperature and relative humidity upto 90%
22. Ambient room temperature	: 10 - 45°C
23. Humidity in ambient (for normal operation)	: < 80%
24. Dust in ambient environment (for normal operation)	: normal lab environment
25. Mobility	: In vendors packing
26. Handling procedure	: Specify
27. A) Maximum $B_{\perp}$ acceptable during operation (at gyrotron location)	: 12 Gs
B) Maximum B_R acceptable during operation (at gyrotron location)	: 4 Gs
28. Shelf life of gyrotron	: 5 yrs
29. Nature of the window	: boron nitride (BN)
(i) Maximum pressurization of window with dry N_2 or CO_2	: + 0.5 bar
(ii) Maximum cantilever load on window (with lateral output)	: < 10kg

(iii) The vendor will ensure that the final microwave beam exiting from the window of the Gyrotron will not have a deviation from the axis of the window greater than ± 0.5 degree.

Note:

1. Gyrotron will be installed on the existing Cryomagnet at IPR

2. The output of Gyrotron would be directly connected to existing MOU unit of installed transmission line system at IPR.

Suggested acceptance tests for Gyrotron:

(A) PRE-DISPATCH INSPECTION TEST AT FACTORY :-

The pre-dispatch inspection will also be carried out at the factory, the suggested acceptance tests are as follows:

1) Mechanical acceptance tests for flaw-less operation of gyrotron:

1. Physical dimension checks as per engineering drawing of the gyrotron.
2. Check of the vacuum in the gyrotron.
3. Check of the vacuum seal on the gyrotron. This check means a 24 hour vac-ion pump off test.
4. Test of hydrostatic pressure on all hydraulic connections carrying the coolant at 1.5 times the rated pressure.

2) Acceptance tests for filament section:

1. Measurement of cold resistance of filament
2. Soft start for filament current dV/dt
3. Measurement of filament current & voltage (as per technical parameters)
4. Insulation check between the cathode and Gyrotron body measured at low voltage (500 V) using megger.
5. Applied Voltage test - 75 KV between cathode and body.
6. Leakage current in all above tests to be measured using standard current transformer or other suitable means-shunt with adequate frequency response. The signal has to be displayed on an oscilloscope with adequate frequency response to detect arc response.
7. Hipotting test at 80 KV dc between cathode and body for required time period.

3) Acceptance tests for cooling of Gyrotron:

Hydrostatic pressure test of Gyrotron would be carried out in all the cooling paths at 1.5 times the rated pressure.

4) Beam voltage tests

1. Applied beam voltage
2. Measured beam current
3. Regulation % during loading
4. Ripple % during loading
5. Body current to be measured during the r.f. pulse and in to absence.

5) RF output (if possible with the subsystems available with the party for High power)

1. The output power would be measured calorimetrically for full parameters (500kW/500ms).
2. Frequency would be measured.

3. Efficiency of the Gyrotron should be measured.

4. Mode purity should be measured/estimated.

5. The harmonic contents at the output should be measured/estimated.

6. The output power CW should be checked with variation from 10% to 100%.

7. Vacuum in the Gyrotron should be measured before and after full power test.

8. The following graphs for the Gyrotron would be generated (if possible with the subsystems available with the party for the high power test of Gyrotron):

a. Beam voltage vs. output power

b. Beam current vs. beam current

c. Anode voltage vs. output power

d. Gun coil current vs. output power (if any other coil other than Cryomagnet)

e. Magnet current vs. output power

f. Heater power vs. output power

g. Beam current vs. heater power

9. Attenuation at the window should be measured/estimated.

10. Leakage at the output window should be measured.

11. Temperature rise of the window (if it is required for 500ms operation) should be measured.

(B) FINAL ACCEPTANCE TEST AT IPR:-

The Gyrotron would be finally accepted at IPR after the successful installation, commission and testing at full parameters (500kW/500ms). The supplier will depute his engineers/scientists for the installation and commissioning of Gyrorton at IPR.
The Final Acceptance tests procedures (at factory and at IPR) would be finalized by mutual agreement with in two months from the date of order.

Details of requirements for installation and commissioning of gyrotron at IPR would be finalized after discussion with the Vendor.

Proposed Acceptance test format at factory and at IPR

a) Acceptance test at Factory

Sr. No.	Parameters	Value as per the Indent Specification	Measured value	Remark
1.	Mechanical			
	a) Dimensional	(As per the drawing)		
	Compatibility with the IPR Magnet	Yes (Diameter)		
	b) Cooling	(1.5 times rated pressure)		
	c) Vacuum Measurement			
		Vac-ion OFF test Vacuum after 24 Hr		
	d) Weight of Gyrotron			
2.	Filament Test			
	Cold resistance			
	Hot Resistance			
	Insulation check between the cathode and body measured using megger.			
	Heater Power (Vf x If)			
	Hi-potting test @ 80kV			

	(1.5 times operating voltage)			
3	HV Test 1. Applied beam voltage 2. Measured beam current 3. Body current to be measured			
4	RF Output test a) Short pulse operation and Burn pattern test b) Mode purity test using IR c) Frequency Measurement d) Harmonic content estimation e) High power test 50kW to 500kW variation f) Pulse duration test 50ms to 500ms g) 500kW 500ms test h) No. of pulses 500kW-500ms i) vacuum in Gyrotron during High power test j) Temperature rise of Gyrotron at 500kW-500ms pulse k) Leakage of microwave from window l) Efficiency	Mode purity > 95% 42GHz ± 0.1 GHz < 5% 500kW ± 5% Min 20 per day for 3 days > 40%		
5	Gyrotron Graphs a. Beam voltage vs. output power b. Beam current vs. beam current c. Anode voltage vs. output power d. Magnet current vs. output power f. Heater power vs. output power			

b) Acceptance test at IPR

The old Gyrotron tube will be removed and new Gyrotron would be installed on the existing cryomagnet system at IPR by the representatives (Engineers/scientists) of the supplier.

All the tests will be repeated at IPR except the mode purity measurement test. The Gyrotron would be tested for 500kW power for 500ms duration.

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(Supply, installation and commissioning of 42GHz Gyrotron Tube on existing ECRH system)

Technical Compliance Sheet

Sr. No.	Specifications	Parameters	Vendor Compliances
1	**Gyrotron Frequency**	42GHz	
2	**Frequency stability**	within ± 0.10 GHz	
3	**Drift of frequency with temperature rise**	within ± 0.10 GHz	
4	**Power**	500kW	
5	**Pulse Duration**	500ms	
6	**Type of Gyrotron**	Depressed Collector	
7	**Nature of the window**	boron nitride (BN)	
8	**Harmonic content**	< 5%	
9	**Efficiency**	45 % or better	
10	**Mode purity**	≥ 95% after MOU	
11	**Critical crater energy**	~ 10 J	
12	**Life time**	5000 filament hours	
13	**Shelf Life**	5 Years	
14	**V.S.W.R**	1.2	
15	**Suitable with ambient room temperature**	10 - 45°C	
16	**Humidity in ambient (for normal operation)**	< 80%	
17	**Factory acceptance test**	by IPR representatives	
18	**Commissioning of Tube at IPR by the Vendors representatives**	Removing the existing tube and commission new and test for full power and duration	

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SINGNATURE WITH NAME & OFFICIAL SEAL

DATE :-