

**STATEMENT OF WORK FOR A 70/105 GHZ
GYROTRON AND ASSOCIATED COMPONENTS
MATERIAL PLASMA EXPOSURE EXPERIMENT
(MPEX)**

Prepared by

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for the
Material Plasma Exposure Experiment Project**

MPEX-03-SOW-001

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CONTENTS

ACRONYMS.....	6
1 INTRODUCTION.....	7
2 SCOPE.....	7
3 APPLICABLE DOCUMENTS.....	7
4 PERFORMANCE REQUIREMENTS.....	7
4.1 COMPANY SUPPLIED MATERIALS.....	7
4.2 TASK 1: QUALITY PLAN AND PROJECT SCHEDULE.....	8
4.3 TASK 2: REVIEW PERFORMANCE SPECIFICATIONS.....	8
4.4 TASK 3: PRELIMINARY DESIGN.....	8
4.5 TASK 4: MAGNET PROCUREMENTS.....	9
4.6 TASK 5: FINAL DESIGN.....	9
4.7 TASK 6: DELIVER GYROTRON #1 AND ASSOCIATED COMPONENTS.....	9
4.8 TASK 7: DELIVER GYROTRON #2 AND ASSOCIATED COMPONENTS.....	10
4.9 PROJECT MANAGEMENT.....	10
4.9.1 Language.....	10
4.9.2 Communications Protocol.....	10
4.9.3 Reporting.....	10
4.9.3.1 Kickoff Meeting.....	10
4.9.3.2 Schedule and Milestones.....	11
4.9.3.3 Monthly Reports.....	12
4.9.3.4 Variance Reporting.....	12
4.9.3.5 Periodic Communications.....	12
5 QUALITY ASSURANCE.....	12
5.1 QUALITY PROGRAM.....	12
5.2 ACCESS FOR SOURCE SURVEILLANCE INSPECTIONS.....	13
5.3 SELLER REQUESTED DEVIATIONS.....	13

5.4 NON-CONFORMANCES.....13

5.5 MEASUREMENT AND TEST EQUIPMENT13

6 TRANSPORTATION13

7 DELIVERABLES13

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MPEX-03-SOW-001

ACRONYMS

DAP	Delivered at Place
ECH	Electron Cyclotron Heating
FAT	Factory Acceptance Test
MOU	Matching Optics Unit
MPEX	Material Plasma Exposure Experiment Project
NIST	National Institute of Standards and Technology
ORNL	Oak Ridge National Laboratory
POC	Point of Contact
PO	Procurement Officer
QAP	Quality Assurance Program
TL	Transmission Line
TPO	Technical Project Officer
SOW	Statement of Work

1 INTRODUCTION

The Material-Plasma Exposure eXperiment (MPEX), a superconducting magnet, steady-state device, is being built at Oak Ridge National Laboratory (ORNL) going forward referred to as “the Company” to address the harsh conditions inside a fusion reactor. This device, as designed, will have the unique feature of being able to conduct accelerated lifetime tests of plasma-facing components, including those that have experienced neutron damage. MPEX will utilize a new high-intensity plasma source concept based on RF technology. This source concept will allow coverage of all expected plasma conditions in the divertor of a future fusion reactor, including very high densities. It will be able to study erosion and redeposition in correct geometries with relevant electric and magnetic fields in front of the target.

The Electron Cyclotron Heating (ECH) system is one of three plasma production and heating systems on MPEX. It consists of a power supply, gyrotron, transmission line, and a launcher that injects the microwaves into the plasma. The ECH system is the primary system to heat electrons in the plasma.

2 SCOPE

This Statement of Work (SOW) applies to a three-part procurement of two dual-frequency gyrotrons to Oak Ridge National Laboratory. The first part of the procurement will be for the preliminary and final design of the gyrotron tube, magnet system, matching optics unit and other associated hardware. The second part will be for the manufacture, assembly, inspection, factory acceptance testing, packaging, shipment and on-site commissioning of the first gyrotron. Part three of this procurement will be for the manufacture, assembly, inspection, factory acceptance testing, packaging, shipment and on-site commissioning of the second gyrotron.

The Seller is expected to demonstrate that the proposed gyrotron system design will comply with the technical requirements through the design package presented at a preliminary design review and at a final design review.

3 APPLICABLE DOCUMENTS

- [1] *Performance Specifications of 70/105 GHz Gyrotron and Associated Components, MPEX-03-SPC-001-R0*

4 PERFORMANCE REQUIREMENTS

4.1 COMPANY SUPPLIED MATERIALS

The Company will supply a matching optics unit to transmission line (MOU-TL) adapter and one or more water-cooled waveguide assemblies for gyrotron testing at the Seller’s facility.

4.2 TASK 1: QUALITY PLAN AND PROJECT SCHEDULE

Prepare a quality plan and a project schedule for the design, manufacture, test and delivery of two dual-frequency gyrotrons and associated equipment. The quality plan shall address how the Seller's Quality Program will be applied to the work in this SOW, and identify procedures and other special documentation for all special processes, measurements etc. The quality plan shall also identify the planned work to be outsourced, list the planned or expected subcontractors and Suppliers, and address how the quality requirements of this SOW will be flowed down to these subcontractors and Suppliers.

The project schedule shall contain sufficient detail so that the Company's Technical Project Officer (TPO) may track design, procurement, fabrication, assembly, testing and shipping activities. The Seller shall propose milestones for tracking progress and payments including at a minimum those listed in Section 4.9.3.2.

4.3 TASK 2: REVIEW PERFORMANCE SPECIFICATIONS

The Seller shall review the performance specifications of the components found in [1] and propose deviations or changes to these specifications. The Company's Technical Project Officer (TPO) will review these changes and update [1] as necessary.

4.4 TASK 3: PRELIMINARY DESIGN

With the completion of Task 2 and with authorization from the TPO, the Seller shall prepare a preliminary design of the gyrotron, magnets, and associated equipment meeting the specifications given in [1]. The Seller shall prepare a preliminary design report and participate in a preliminary design review. The expectation is that the design shall be > 60% completed for the preliminary design review. The preliminary design review will be held by videoconferencing or at the Seller's site based on agreement between the POC and TPO. The Seller shall prepare written meeting minutes and submit them to the TPO for review within 3 working days after the meeting. Completion of the preliminary design review and closure of all chits (or issues) shall constitute a project milestone.

The Preliminary Design Review shall:

- Include mechanical assembly drawings
- Include major piece part assemblies
- Include performance modeling results
- Include the polarization direction at the output of the MOU
- Include preliminary interface descriptions
- Including thermal and fatigue lifetime analyses under different operating scenarios (i.e., depressed collector vs. non-depressed collector operation)
- Include magnet specifications and procurement schedule

4.5 TASK 4: MAGNET PROCUREMENTS

After completion of Task 3 and with approval of the TPO, the Seller may proceed with the procurement of the gyrotron magnet systems.

4.6 TASK 5: FINAL DESIGN

After completion of Task 3 and with approval of the TPO, the Seller shall prepare a final design of the gyrotron, magnets and associated hardware meeting the specifications given in [1]. The Seller shall prepare a final design report and participate in a final design review. The final design review will be held by videoconferencing or at the Seller's site based on agreement between the POC and TPO. The Seller shall prepare written meeting minutes and submit them to the TPO for review within 3 working days after the meeting. The expectation is that the Seller shall be ready for manufacturing upon approval of the final design. Completion of the final design review and closure of all chits (or issues) shall constitute a project milestone.

The final design review shall:

- Address findings from Preliminary Design Review
- Include final performance modeling
- Include final mechanical drawings
- Include final interface definitions
- Water chemistry specifications
- Component masses
- Collector sweep magnet specifications (if applicable)
- Gyrotron operating magnetic field specification
- Maximum magnetic field strength in magnet main coils
- Magnetic field profiles within magnet bore
- Magnet control system supply current specification
- Magnet cold head helium gas pressure and flow specifications
- Address planned major item procurements
- Address magnet system progress
- Review the Factory Acceptance Test Plan
- Review the Startup and Commissioning Plan

4.7 TASK 6: DELIVER GYROTRON #1 AND ASSOCIATED COMPONENTS

Upon successful completion of Task 5 and with authorization of the TPO, the Seller shall fabricate, assemble, test, and deliver a gyrotron, primary magnet, and matching optics unit in accordance to the approved final design from Task 5 meeting the specifications in [1]. The Seller shall provide personnel to perform installation oversight, and to support the commissioning and site acceptance testing.

Final acceptance of gyrotron #1 and associated components will occur upon successful completion of the site acceptance tests at the Company's facility.

4.8 TASK 7: DELIVER GYROTRON #2 AND ASSOCIATED COMPONENTS

Upon successful completion of the factory acceptance tests on gyrotron #1 and with authorization of the TPO, the Seller shall fabricate, assemble, test and deliver a gyrotron, primary magnet, and matching optics unit in accordance to the approved final design from Task 5 meeting the specifications in [1]. The Seller shall not begin final assembly of gyrotron #2 until factory acceptance tests of gyrotron #1 are complete. With approval of the TPO, fabrication of components for assembly of gyrotron #2 may begin before completion of factory acceptance tests on gyrotron #1. If design changes are required based on the results of the fabrication, assembly and testing of Gyrotron #1, the final design report from Task 5 shall be updated, and a design review held to review and approve these changes before assembly of gyrotron #2 can commence. The Seller shall provide personnel to perform installation oversight, and to support the commissioning and site acceptance testing.

Final acceptance of gyrotron #2 and associated components will occur upon successful completion of the site acceptance tests at the Company's facility.

4.9 PROJECT MANAGEMENT

4.9.1 Language

All communications and documentation shall be in English.

4.9.2 Communications Protocol

The Seller shall designate an official single Point of Contact (POC) to interface with the Company's Technical Project Officer (TPO). Only the Company's Procurement Officer (PO) can authorize changes to the price or work scope. SOW or Technical Specification updates can only be issued to the Seller by the Company's PO.

Problems encountered or anticipated shall be communicated as soon as practical.

Monthly reports shall be submitted by the seventh calendar day of each month or on the Seller's usual reporting schedule as mutually agreed between the TPO and the Seller's designated POC.

4.9.3 Reporting

4.9.3.1 Kickoff Meeting

The kickoff meeting will be scheduled at a mutually agreed time as soon as practical after award of the subcontract. The Seller is responsible for recording meeting minutes and submitting these to the TPO within 3 working days after the meeting.

The primary purpose for the kickoff meeting is to confirm that the project participants understand the terms and conditions of the subcontract, SOW, specifications, and work activities.

The following topics will be discussed:

1. Flowdown requirements.
2. Work activities, schedules, and deliverables
3. Expectations for satisfying quality standards and documentation

4.9.3.2 Schedule and Milestones

At a minimum, the project schedule shall include the following activities or milestones:

- Early draft mechanical and electrical interface drawings released
- Preliminary Design Review
- Magnet system Design Review and acceptance test plan review
- Magnet system purchase released
- Preliminary Design Review findings updated
- Final Design Review
- Gyrotron long lead time items ordered
- Magnet system acceptance tests complete
- Magnet system delivered to seller
- Begin gyrotron and MOU fabrication
- Gyrotron #1 subassemblies complete
- Gyrotron #1 window subassembly complete and leak tested
- Gyrotron #1 final assembly
- Gyrotron #1 bakeout
- Gyrotron #1 in test stand
- Gyrotron #1 short pulse high power results witnessed
- Gyrotron #1 Steady-state testing witnessed
- Gyrotron #1 with MOU and magnet shipped
- Gyrotron #2 subassemblies complete
- Gyrotron #2 window subassembly complete and leak tested
- Gyrotron #2 final assembly
- Gyrotron #2 bakeout
- Gyrotron #2 in test stand
- Gyrotron #2 short pulse high power results witnessed
- Gyrotron #2 Steady-state testing witnessed
- Gyrotron #2 with MOU and magnet shipped
- Site acceptance of Gyrotron #1
- Site acceptance of Gyrotron #2

4.9.3.3 Monthly Reports

Monthly reports shall be submitted by the seventh calendar day of each month or on the Seller's usual reporting schedule as mutually agreed between the TPO and the Seller's designated POC.

Monthly report data shall include actual schedule progress, milestones reached, corrective actions needed, display of the present critical path for the Seller's work, and a brief narrative describing the status of work, significant accomplishments, actual and potential problems and risk mitigations or corrective actions.

4.9.3.4 Variance Reporting

The Seller shall notify the TPO and the PO immediately in writing when it is determined the actual cost may exceed the Agreement price. In no case shall the Seller continue work without authorized funding if it is determined that actual cost may exceed the Agreement price.

4.9.3.5 Periodic Communications

The Seller shall participate in a bi-weekly phone conference to be held with the Company's TPO to discuss any technical issues and schedule, personnel, and any other items pertinent to the work activities. The bi-weekly phone conference will serve as a mechanism to get early visibility of problems and issues arising during the performance of this subcontract. The Seller shall prepare written meeting minutes and submit these to the TPO within 3 working days after the meeting.

5 QUALITY ASSURANCE

5.1 QUALITY PROGRAM

The Seller shall have a verifiable Quality Assurance Program (QAP) that, at a minimum, is ISO 9001 certified, but preferably NQA-1 2008/2009a or equivalency. The Seller shall be able to demonstrate that it can fulfill the quality assurance requirements in this SOW and in [1]. At a minimum, the prospective supplier shall have an established, documented, and effectively implemented quality assurance program describing controls for: work processes (controlled by instructions/procedures), personnel training and qualification, document and records control, design, procurement, inspection and testing; including the use of measuring and test equipment when used, corrective action, and assessments (audits).

Prior to subcontract award, the seller's QAP shall be evaluated to determine the degree of effective implementation of the quality program. Deficiencies, if any, identified during the evaluation shall be addressed and corrected to the satisfaction of the Company, and correction shall occur prior to award.

All suppliers/sub-suppliers, subcontractors and fabricators (as applicable) shall have a Quality Assurance Program that meets or exceeds the requirements listed above.

5.2 ACCESS FOR SOURCE SURVEILLANCE INSPECTIONS

As part of the Company's quality assurance program, the Company reserves the right to perform source surveillance activities at the Seller's facility or any sub-tier seller facility that the Company determines necessary to ensure that quality requirements are met.

5.3 SELLER REQUESTED DEVIATIONS

The Seller shall propose any deviations to the specifications, drawings, or other technical requirements during the Review of Specifications per Section 4.3 and obtain the Company's approval prior to invoking the deviation. Any Deviation Requests arising from the fabrication phase shall adhere to the Seller's Quality Program procedure and must be approved by the TPO.

5.4 NON-CONFORMANCES

When a nonconformance is identified, the Seller shall notify the Company TPO to determine what actions are required and document the nonconformance following the Seller's Quality Program procedure. All nonconformances shall be summarized in the Final Report. Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. Controls shall provide for identification, documentation, evaluation, segregation when practical, disposition of the nonconforming items, and for notification to the Company.

5.5 MEASUREMENT AND TEST EQUIPMENT

Tools, gages, instruments, and other measurement and test equipment used for activities affecting quality shall be controlled, calibrated at specified periods, adjusted, and maintained to required accuracy limits.

Measurement and test equipment used by the Seller to perform work under this Statement of Work must be calibrated and traceable to NIST standards. Calibrations must be current. Calibration records must be provided to the Company.

6 TRANSPORTATION

The equipment shall be packaged in accordance to [1]. Any special lifting fixtures or related hardware that are required to move, load, or unload the equipment shall be considered part of the equipment. Any special lifting fixtures or related hardware that are required to move, load, or unload the equipment shall be considered part of the equipment. Incoterms: Delivered at Place (DAP) (ORNL Facility – Oak Ridge TN).

7 DELIVERABLES

The Seller shall provide the following deliverables:

Deliverable 1 – Within 2 weeks of subcontract award, provide to the TPO the Seller's Quality Assurance Program documentation and a project specific Quality Plan.

Deliverable 2 – Within 2 weeks of subcontract award, provide to the TPO a list of proposed deviations to performance specifications given in [1].

Deliverable 3 – Preliminary design review shall be held no more than 4 months after subcontract award and shall include the following documents:

- Preliminary design review report
- All drawings and information called for in Section 4.4
- Presentation slides and documents

Deliverable 4 – Final design review shall be held no more than 7 months after subcontract award and shall include the following documents:

- Resolution of preliminary design review findings
- All documents, drawings, specifications and information called for in Section 4.6
- Final Presentation slides and documents

Deliverable 5 – Gyrotron #1 shall be delivered to the Company site no more than 21 months after contract award and shall include:

- Magnet with integral cryo-cooler
- Matching optics unit
- Collector magnet sweep amplifier system (if required)
- Cryo-cooler compressor and associated pressurized helium lines
- Magnet controls mounted in a rack
- Cables for controls
- Complete FAT report and data
- Operations and maintenance manual

Deliverable 6 – Complete Gyrotron #1 Commissioning and Acceptance Tests at the Company's facility no more 3 months after delivery of gyrotron to the Company's facility. Seller shall provide personnel to supervise the installation and commissioning of the gyrotron. This deliverable will not be complete until Company acceptance of the final Commissioning and Acceptance test report.

Deliverable 7 – Gyrotron #2 shall be delivered to the Company site no more than 24 months after contract award and shall include:

- Magnet with integral cryo-cooler
- Matching optics unit
- Collector magnet sweep amplifier system (if required)
- Cryo-cooler compressor and associated pressurized helium lines
- Magnet controls mounted in a rack

- Cables for controls
- Complete FAT report and data
- Operations and maintenance manual

Deliverable 8 – Complete Gyrotron #2 Commissioning and Acceptance Tests at the Company's facility no more 3 months after delivery of gyrotron to the Company's facility. Seller shall provide personnel to supervise the installation and commissioning of the gyrotron. This deliverable will not be complete until Company acceptance of the final Commissioning and Acceptance test report.