Statement of Work for MPEX Magnet Systems MATERIAL PLASMA EXPOSURE EXPERIMENT (MPEX)

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Statement of Work for MPEX Magnet Systems for the Material Plasma Exposure Experiment Project

MPEX-02-ENG-001, Rev. 0

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Change Log

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1 INTRODUCTION

The Material Plasma Exposure Experiment (MPEX) is a new world-leading linear plasma device (LPD) for testing fusion reactor divertor materials and components by exposing them to fusion reactor divertor–relevant plasma conditions. MPEX is designed to facilitate hazardous materials such as neutron-activated materials as well as liquid metals. MPEX is a steady-state device for fusion reactor–relevant plasma fluence exposures, enabling the development of plasma-facing components up to a technical readiness level of 6 for certain end-of-life studies

A key element in MPEX is the Magnet System, which provides the necessary and spatially variant magnetic field along its length in order to enable plasma heating and sources while confining the plasma as it travels from source to target.

2 SCOPE

This statement of work (SOW) encompasses the final design, manufacture, inspection, testing, and packaging of the Magnet System for the Material Plasma Exposure eXperiment (MPEX) for Oak Ridge National Laboratory (going forward referred to as the Company). For the purposes of this SOW, the MPEX Magnet System is referred to as "equipment." The equipment will consist of seven independently operated magnet sub-systems (see Figure 2-1):

- 1.) Upstream Helicon Magnet Sub-System provides necessary upstream mirror fields for helicon plasma source,
- 2.) *Helicon Source Magnet Sub-System* provides fields along length of the helicon plasma source
- 3.) *Downstream Helicon Magnet Sub-System* provides necessary downstream mirror fields for helicon plasma source,
- 4.) *ECH Magnet Sub-System* provides the field profile to accommodate resonant zones for electron cyclotron heating (ECH) of the plasma
- 5.) *ICH Magnet Sub-System* provides the field profile to accommodate ion cyclotron heating (ICH) at the 60-cm long ICH antennae
- 6.) *Transport Magnet Sub-System* provides the field profile to limit the expansion of the plasma from the ICH to the target and maintain the necessary distance between the ECH heating and target areas
- 7.) *Target Magnet Sub-System* provides the field profile in the target area.

With respect to "magnet sub-system", the "magnet sub-system" is defined as all hardware, structures, and components including instrumentation and power supply systems that are required to provide the necessary magnetic field for the equipment.

Sharing a common axial alignment, each sub-system is a solenoid coil geometry that provides a specific field profile along facility length while providing field in the interface regions between

sub-system to prevent un-necessary plasma expansion. It is expected that the MPEX Magnet System will use a combination of superconducting (SC) and room temperature (RT) magnet technologies as appropriate for each sub-system in order to provide the necessary magnetic fields outlined in the Technical Specification for the MPEX Magnet System [1].



Figure 2-1: MPEX magnet system layout for the base preliminary design.

3 APPLICABLE DOCUMENTS

- [1] Technical Specification for the MPEX Magnet System, MPEX-02-ENG-002.
- [2] MPEX Magnet Test Plan, MPEX-02-ENG-003.

4 PERFORMANCE REQUIREMENTS

4.1 SELLER RESPONSIBILITIES

4.1.1 Technical Requirements

The Seller shall design, procure, manufacturer, inspect, test, package and supply the magnet subsystems in accordance with the technical requirements defined in the Technical Specification for the MPEX Magnet System [1]. The magnet sub-systems can be supplied in their entirety or in groups sharing common design features with a preference toward inner diameters as specified in [1] resulting in the following three groups:

Group 1 – Small Diameter RT Magnets – Helicon Source Magnet Sub-System

- Group 2 Small Diameter SC Magnets Upstream Helicon Magnet Sub-System, Downstream Helicon Magnet Sub-System, ECH Magnet Sub-System, & ICH Magnet Sub-System
- Group 3 Large Diameter SC Magnets Transport & Target Magnet Sub-systems

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4.1.2 Tooling, Fixtures, and Test Equipment

The Seller shall furnish all materials required to manufacture, test, inspect, document, and package the equipment under this SOW.

4.1.3 Packaging

The Seller shall package and prepare each piece of equipment for shipment to meet the requirements set forth in Technical Specification for the MPEX Magnet System [1].

4.1.4 Packaging Report

The Seller shall prepare a Packaging Report. The Packaging Report shall include, at minimum, the following information:

- Number of crates
- Crate identification
- Detail of crate contents
- Handling Requirements
- Description of Transportation Monitoring Equipment

4.1.5 Operation and Maintenance Manual

Seller shall provide all manuals and documentation that is required for each sub-system of the equipment.

4.1.6 Design Package

Seller shall provide an "as-built" Design Package for each sub-system that reflects the acceptance design documentation for the equipment.

The following types of documentation as well as any other related documents that serve as the design basis for the equipment shall be included as part of the Design Package.

- Final Design Package (see section 7.3)
- 3D CAD models and 2D CAD drawings
- manufacturing and construction drawings
- bills of materials
- material and component specifications

4.1.7 Validation and Verification

The Seller shall develop and document test or inspection procedures including acceptance criteria for validating and verifying compliance of the equipment with the Technical Specification for the MPEX Magnet System [1]. These test or inspection procedures shall be consistent with the test and inspection criteria outlined in the MPEX Magnet Test Plan [2]. This set of test and inspection procedures will be provided during the Final Design Review

4.1.8 Support Capability

The Seller shall provide support capability of the equipment for a minimum of one (1) year from the date of delivery. This support capability shall include the ability to address any necessary repairs to the MPEX magnet sub-systems during their final assembly.

4.1.9 Deliverables

The Seller shall comply with the deliverables requirements listed in Section 7.

4.2 PROJECT MANAGEMENT

4.2.1 Point of Contact

The Seller shall designate an official single Point of Contact (POC) to interface with the Company Technical Project Officer (TPO) and Procurement Officer. Technical issues shall be discussed with the Company's TPO. Subcontract administration issues shall be discussed with the Company's Procurement Officer. Changes to the SOW or Technical Specification can only be officially authorized by the Company's Procurement Officer

4.2.2 Desired Delivery Date of Equipment

With respect to desired delivery date, it is desired that final design of the MPEX magnet systems and all equipment is delivered to the Company no later than 36 weeks after receipt of order (ARO)

Should multiple Sellers be involved in distributing groups of the magnet sub-systems listed in section 4.1.1, the desired delivery dates are as follows:

<u>Group 1 – Small Diameter RT Magnets – Helicon Source Magnet Sub-System, no later than</u> <u>18 months ARO</u>

<u>Group 2 – Small Diameter SC Magnets – Upstream Helicon Magnet Sub-System,</u> <u>Downstream Helicon Magnet Sub-System, ECH Magnet Sub-System, & ICH</u> <u>Magnet Sub-System; no later than 36 months ARO</u>

<u>Group 3 – Large Diameter SC Magnets – Transport & Target Magnet Sub-systems; no later</u> <u>than 30 months ARO</u>

4.2.3 Meetings/Teleconferences

4.2.3.1 Kickoff Meeting

The Seller shall have a Kickoff Meeting with the TPO and other members of the Company's project team at a mutually agreeable time upon notification of ARO and designation of the POC. This should occur no later than 15 days after ARO. The primary purpose for the teleconference is to exchange contact information between the teams and discuss the following topics that are related to the SOW and the Technical Specifications.

- Scope and content of the final design for the MPEX Magnet System
- Draft Project Plan that outlines relationships among work activities, schedules, and deliverables as defined in the Project Plan
- Expectations for satisfying quality standards, documentation requirements, delivery arrangements, acceptance criteria, and payment schedules

4.2.3.2 <u>LLP Preliminary Design Review</u>

Seller shall present preliminary magnet system design and supporting technical documentation at MPEX Magnet LLP Preliminary Design Review. This meeting shall be held no later than three months after ARO. This meeting will either be in-person or by video conference and will be coordinated by the Company with the Seller. Documentation that should be prepared for this review includes

- Detailed solid models that represent at least 50% or greater design completion
- Detailed mechanical, thermal, and electromagnetic analysis that address key technical performance issues such as mechanical loading, quench protection of superconducting magnet sub-systems as applicable and estimated cooling loads,

This shall include all backup material previously submitted and revised, as necessary, all design calculations, all explanatory material giving the design rationale for any design decisions which would not be obvious to an engineer reviewing the drawings and specifications, and any information for the Resident Engineer that will assist in administering the contract

- Draft bill of materials for key components of the equipment.
- Updated resource loaded schedule for the MPEX system manufacturing including
- Draft Seller Acceptance Testing
- Design Compliance Matrix (DCM) which shows how each of the requirements in the technical specification are met, either by analysis, demonstration, inspection, or test.

In draft bill of materials, the Seller can designate materials/components that could benefit from early acquisition due to long-lead times (e.g. cryocoolers). Justification shall be provided by the

Seller to the Company that clearly outlines 1.) the benefits for this early acquisition, 2.) specifications for the materials/components relative to the preliminary design, 3.) maturity of the design relative to these materials/components, & 4.) supplier cost & schedule quotes for materials/compenents. This justification would be reviewed by the Company during the LLP Preliminary Design Review and approval/authorization would be provided by the Company TPO through the Company Procurement Officer to the Seller POC.

Completion of the preliminary design represents key deliverable to this procurement.

4.2.3.3 <u>LLP Final Design Review</u>

Seller shall have a Final Design Review prior to the start of fabrication for each MPEX magnet sub-system for review of build-to-print drawings and manufacturing inspection plan. This meeting shall be held no later than six months after ARO. Like the Preliminary Design Review, this meeting will either be in-person or by video conference and will be coordinated by the Company with the Seller. A manufacturing inspection plan should include build-to-print drawings and the resource loaded schedule for the assembly and fabrication including key dimensional inspections and hold points.

Completion of the final design represents key deliverable to this procurement.

4.2.4 Project Schedule

As stated

4.2.5 Shipping Release

The Seller shall request a Shipping Release from the Company after the equipment is prepared for shipping.

4.2.6 Manufacturing Dossier

The Seller shall prepare a Manufacturing Dossier for each individual piece of equipment.

5 QUALITY ASSURANCE

The quality of work performed under this SOW will be controlled by the Seller assigning the appropriate, knowledgeable, and qualified personnel and sub-sub tier vendors to this task, providing facilities and manufacturing equipment, and following a rigorous quality assurance plan.

This section establishes QA program requirements. QA requirements for products are not specified in Section 5 but rather in specifications and implementing manufacturing plans and procedures.

QA program requirements may include; however, are not limited to the following:

- Standards for Seller QA program
- Quality Plans made specifically for the contract, identifying how the specific contract requirements will be fulfilled.
- Right of access for inspection, surveillance, and audit
- Subcontractor's responsibility for conformance
- Identification of non-conforming items and responsibility for taking corrective action
- Requirements for documentation (planning, process, and final verification)
- General conduct of inspections and tests (information for each test or inspection is in a specification)
- Manufacturing inspection and test plans, enabling coordinated scheduling of independent inspection of oversight of work in process by the Company
- Identification and traceability requirements
- Calibration of measuring and test equipment
- Control of special processes
- Shipping release
- Receiving and inspection

5.1 QUALITY PROGRAM

The Seller's Quality Assurance Program (QAP) shall be implemented and able to demonstrate that it can fulfill the quality assurance requirements delineated within the Statement of Work (SOW) and Technical Specification. At a minimum, the prospective supplier shall have an established, documented, and effectively implemented quality assurance program(e.g. ISO 9001 and/or NQA-1 2008/2009Addendum program equivalency or Company-approved equivalent) describing controls for: Design/Design Control, work processes (controlled by instructions/procedures), personnel training and qualification, document control and records management, procurement, control of purchased items and services, inspection and testing; including the use and control of measuring and test equipment when used, corrective action, and assessments (audits), handling, storage and shipping. Furthermore, if determined necessary and as a prerequisite to contract 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 shall occur prior to award. ORNL shall retain the right to perform an initial audit of the prospective supplier to evaluate the degree of compliance with requirements delineated in the SOW and Technical Specification, as well as source inspections at predetermined frequencies throughout the performance of the contract. Changes to the QAP must be approved, in advance by the Company prior to implementation.

The quality program shall be based on existing proven work routines and practices described in written Seller documents reflecting a planned and systematic approach to achieving and maintaining quality.

All suppliers/sub-suppliers, subcontractors to the Seller and fabricators (as applicable) shall provide products that meet the established industry codes and standards invoked herein.

5.2 QUALITY PLAN

The Seller shall prepare a Quality Plan specifically for this subcontract. The Quality Plan shall identify how the Seller will fulfill the specific subcontract requirements. This plan is in addition to the pre-established quality program. The Quality Plan (QP) is an implementation document that describes how the Seller will comply with the requirements of the governing SOW. The QP should incorporate elements (e.g. procedures) of the Seller's Quality Program as much as possible.

Material procurements and manufacturing on the subcontract may not begin until notice is received that the Quality Plan is approved by the Company.

5.3 CONFLICT

In the event of a conflict between the Technical Specification and the Statement of Work, the Seller shall notify the Company's TPO and Procurement Officer. The TPO and Procurement Officer will determine which document takes precedence and advise the Seller with written communications, accordingly. Failure to notify the Company of any such conflict shall not relieve the Seller of any responsibility to meet all requirements.

5.4 ACCESS FOR SOURCE SURVELLIANCE INSPECTIONS

As part of the MPEX Quality Assurance Program Plan, source surveillance activities may be conducted at the Seller's facility or any sub-tier seller facility that the Company determines necessary to ensure quality objectives are met. Representatives of the Company may accompany the source surveillance team and inspectors as observers. Such surveillance may include auditing and monitoring of production processes, in-process inspection and controls, chemical or physical certifications, final inspection and tests, preparation for shipment, and review of certification data. The Seller shall provide the source surveillance team and inspectors including observers' access to all data and operating areas pertinent to the subcontract. Source surveillance by the Company representatives, source surveillance team, or inspectors shall not constitute equipment acceptance by the Company and shall in no way relieve the Seller of the responsibility to furnish acceptable items.

5.5 TEST AND INSPECTIONS

Testing and Inspection requirements are addressed in technical specifications.

The Company has the right to witness all tests and inspections.

Calibrations records shall be available for all measurement tools.

5.6 SELLER-REQUESTED DEVIATIONS

The Seller may propose deviations from the specifications, drawings, or other technical requirements of this procurement. Where time is a consideration, the Seller may communicate the proposed deviation directly to the (TPO) (via e-mail correspondence), with a copy to the Company's Procurement Officer. The request is to identify the affected items, drawing/specification number and revision number, a description of the proposed deviation, and the justification for it. The TPO will evaluate the technical aspects, along with MPEX Quality Representative concurrence and document a recommendation acceptance/disapproval (cannot be verbal) to the Company's Procurement Officer, who will communicate acceptance or disapproval to the Seller.. Deviation requests are to be submitted on the Company's Deviation Request (DR) Form. An accepted DR does not establish a precedent or obligation to accept existing or future items not conforming to all provisions of the subcontract

5.7 NON-CONFORMANCES

The Company expects to receive equipment items, components, materials, software, and documentation that conform to all codes, standards, specifications, and procedures in the contract. When a non-conformance is identified at any point during contract performance the condition shall be documented and reported to the Company. The Seller shall:

- 1) Identify and segregate when practical, the non-conforming item,
- 2) Stop any further work on the item until an acceptable disposition is achieved,
- 3) Document and report the occurrence to the Company in a Non-Conformance Report (via email, copy of internal NCR Form, Or Company's NCR form partially completed) to the TPO, with a copy to the Procurement Officer and MPEX Quality Representative, as soon as reasonably possible.

The Non-Conformance Report should contain or refer to all relevant material available to enable an informed decision on the definite course of action to be taken. At a minimum, this report should outline the issue, provide details on how it could or could not affect the performance, safety, reliability, operability, traceability, interchangeability, or regulatory requirements, and provide remediation of the issue as applicable.

The Company TPO will review and discuss the Non-Conformance Report with the Seller and based on the review, either return the Non-Conformance to the Seller POC with approval to provide any additional details, action items, proposed dispositions, and justifications with resolution for the Seller to implement prior to resuming work.

5.8 TRAVELERS

The Seller shall maintain copies of all completed travelers used in the manufacturing process of each piece of equipment. These documents may include, but are not limited to mill certifications, material test reports, inspection data, and testing results.

5.9 CERTIFICATE OF CONFORMANCE

The Seller shall prepare a Certificate of Conformance for each individual piece of equipment in accordance with their Quality System process for issuing such certificates. The Certificate of Conformance shall state that the equipment meets all requirements defined in the Technical Specification for MPEX Magnet System and this Statement of Work. The POC shall submit the completed Certificate of Conformance to the TPO.

The Seller may use any suitable format for the Certificate of Conformance. At minimum, the Certificate of Conformance shall include:

- Manufacturer's details (name, address, etc.)
- Equipment identification details (model, serial number, etc.)
- Declaration that the equipment meets the applicable requirements
- Performance data (including Calibration and Test Certificates)
- Any standards the equipment complies with
- Signature of Sellers's authorized representative
- Reference to the Suppliers Quality System section for issuing the Certificate of Conformance

6 TRANSPORTATION

Packaging, including all required material, and shipping are the responsibility of the Supplier. Each magnet shall be thoroughly cleaned to remove any oils, grease, dirt, chips, etc. that may have accumulated on the equipment during testing. Each magnet shall be packaged individually in wooden shipping containers with proper bracing and placed on wooden platforms to avoid any damage during handling and shipping. Potential contact points between the magnet and the crate shall be padded to prevent damage during shipping. The exterior of the container shall provide access for moving the container by forklift. Shock indicators (e.g. Shockwatch) and tilt indicators (e.g. Tip-n-tell) shall be placed on the exterior of the container. The packaging plan and the container design shall be submitted to ORNL for approval prior to the construction of the shipping containers. Supplier shall notify ORNL 10 business days prior to shipment.

7 DELIVERABLES

The Seller shall prepare the following deliverables and submit them to the TPO within the specified number of working days. The term "working day" is defined as any day except Saturday, Sunday, or a holiday.

7.1 POC DESIGNATION

The POC Designation shall be in the form of an e-mail sent to the TPO with a copy to the Procurement Officer. The POC Designation shall be completed within 5 working days ARO. The TPO will reply and acknowledge the message was received.

7.2 QUALITY PLAN

A draft Quality Plan shall be sent to the TPO for comment within 30 working days AOC. The TPO, Quality Assurance Representative and others as deemed appropriate will comment and return the draft Quality Plan to the POC within 20 working days for comment resolution. The POC shall make any changes and return the revised draft Quality Plan to the TPO within 15 working days. If the TPO and the MPEX QA Representatives deem the revised draft Quality Plan to be acceptable, the TPO and the MPEX QA Representatives will sign the Quality Plan and return it to the POC within 10 working days. Each version of the Quality Plan sent to the TPO shall be signed by the POC. If an on-site audit of the Seller is deemed necessary by the Company, the TPO and POC shall schedule the audit at an agreed upon time. Upon acceptance by the Company within 15 working days after AOC, the TPO will sign the Quality Plan.

Approval of the Quality Plan by the Company represents a Hold Point. Materials procurement and manufacturing operations shall not commence until the Hold Point is released. Return of the signed Quality Plan by the TPO to the POC constitutes a Hold Point release.

7.3 PRELIMINARY DESIGN PACKAGE

As previously stated, the Seller shall complete the preliminary design for the MPEX Magnet System or Sub-Systems. This preliminary design of the MPEX Magnet System and Magnet Sub-Systems shall include detailed solid models, mechanical, thermal, and electromagnetic analysis that address key technical performance issues such as mechanical loading, quench protection of superconducting magnet sub-systems as applicable, estimated cooling loads.

It is expected that regular communication between Seller and the Company will occur during the final design, this preliminary design package will be presented for review at the LLP Preliminary Design Review described in Section 4.2.3, no later than three months after ARO.

The Preliminary Design Package shall be reviewed, findings and recommendations will be shared no later than 10 working days after completion of the review. Seller shall address any outstanding

issues no later than 15 working days upon receipt of findings. The TPO will review for compliance to findings as applicable. Signature of the Final Design Package by the TPO shall be achieved within 25 working days after receipt of the Final Design Package.

Approval of the Preliminary Design Package by the Company represents a Hold Point. Procurement or manufacturing operations shall not commence until the Hold Point is released. Return of the signed Design Package by the TPO to the POC constitutes a Hold Point release.

For those items that the Seller has designated within draft bill of materials as materials/components that could benefit from early acquisition due to long-lead times (e.g. cryocoolers), justification shall be provided by the Seller to the Company per the guidance in section 4.2.3 for review by the Company. This justification would be reviewed by the Company and if benefit to the project has been clearly demonstrated, approval/authorization would be provided by the Company TPO through the Company Procurement Officer to the Seller POC.

7.4 FINAL DESIGN PACKAGE

As previously stated, the Seller shall complete the final design for the MPEX Magnet System or Sub-Systems. This final design of the MPEX Magnet System and Magnet Sub-Systems shall include build-to-print drawings, manufacturing inspection plan, and magnet test plan for each MPEX magnet subsystem. Documentation supporting technical issues identified during Preliminary Design shall be provided.

It is expected that regular communication between Seller and the Company will be occurring during the final design, but this final design package will be presented for review at the LLP Final Design Review described in Section 4.2.3, no later than six months after ARO.

The Final Design Package shall be reviewed ,findings and recommendations shall be shared no later than 10 working days after completion of the review. Seller shall address any outstanding issues no later than 15 working days upon receipt of findings. The TPO will review for compliance to findings as applicable. Signature of the Final Design Package by the TPO shall be achieved within 25 working days after receipt of the Final Design Package.

7.5 MANUFACTURING INSPECTION PLAN

The Seller shall provide a manufacturing inspection plan (MIP) for each magnet sub-system prior to the start of fabrication that includes build-to-print drawings and outlines the resource loaded schedule for the assembly and fabrication including key dimensional inspections and hold points. This MIP shall be reviewed and approved by the TPO prior to the start of manufacturing. Return

of the signed MIP by the TPO to the POC constitutes a Hold Point release for each magnet subsystem.

7.6 MAGNET TEST PLAN

The Seller shall provide a magnet test plan (MTP) that outlines the testing that will be performed during assembly and performance testing of the magnet sub-systems. This magnet test plan shall be specific to the MPEX magnet sub-systems and consistent with the expectations outlined in the Company MPEX MTP.

This test plan shall also include procedures detailing the cooldown and warmup management of the SC magnet sub-system. These procedures shall reflect the rate of cooldown or warm up that addresses potential thermal contraction and contamination issues especially if liquid nitrogen is used to pre-cool the inner LHe vessel.

This MTP shall be reviewed and approved by the TPO prior to the start of manufacturing. Return of the signed MTP by the TPO to the POC constitutes a Hold Point release for each magnet subsystem.

7.7 MAGNET ACCEPTANCE TESTING REPORT

The Seller shall provide a test report summarizing the performance of each MPEX magnet subsystem to the Seller (section 7.5). This test report shall be reviewed for compliance and signature of the final report will be provided by the TPO to the POC prior to the shipment of each MPEX magnet sub-system. This approval constitutes a Hold Point release.

7.8 EQUIPMENT

The equipment may be subjected to inspection and testing upon arrival at the Oak Ridge National Laboratory. A Certificate of Final Acceptance will be issued to the POC no later than 100 working days after equipment arrival at the at the Oak Ridge National Laboratory

Signature of the Certificate of Final Acceptance by the TPO represents a Hold Point. The subcontract cannot be closed until the Hold Point is released. Issuance of the signed Certificate of Final Acceptance to the POC constitutes a Hold Point release.

7.9 CONTRACTORS RELEASE NOTE

The Seller shall submit a Contractors Release Note to the TPO within 5 working days after the completion of manufacturing and testing processes. The Seller shall submit the completed Manufacturing Dossier along with the Contractors Release Note. The TPO will either sign and return or comment and return the Contractors Release Note within 5 working days.

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Signature of the Contractors Release Note by the Company represents a Hold Point. Packaging operations shall not commence until the Hold Point is released. Return of the signed Contractors Release Note by the TPO to the POC constitutes a Hold Point release.

7.10 SHIPPING RELEASE

The Seller shall request a Shipping Release from the TPO at least 10 working days before the expected shipping date. The Seller shall submit the completed Packaging Report along with the Shipping Release request. The TPO will either sign and return or comment and return the Shipping Release within 5 working days.

Signature of the Shipping Release by the Company represents a Hold Point. The equipment shall not be shipped until the Hold Point is released. Return of the signed Shipping Release by the TPO to the POC constitutes a Hold Point release.